Public Health Assessment

Initial Release

PORTLAND HARBOR
PORTLAND, OREGON

EPA FACILITY ID: ORSFN1002155

Prepared by the
Oregon Department of Human Services

OCTOBER 6, 2009

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Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

Section 104 (i) (7) (A) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, states "…the term 'health assessment' shall include preliminary assessments of potential risks to human health posed by individual sites and facilities, based on such factors as the nature and extent of contamination, the existence of potential pathways of human exposure (including ground or surface water contamination, air emissions, and food chain contamination), the size and potential susceptibility of the community within the likely pathways of exposure, the comparison of expected human exposure levels to the short-term and long-term health effects associated with identified hazardous substances and any available recommended exposure or tolerance limits for such hazardous substances, and the comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure.

In accordance with the CERCLA section cited, ATSDR's Cooperative Agreement Partner has conducted this health assessment on readily available site data. Additional public health assessments may be conducted for this site as more information becomes available to ATSDR's Cooperative Agreement Partner.

The conclusions and recommendations presented in this public health assessment are the results of site-specific analyses and are not to be cited or quoted in other evaluations or public health assessments.

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Oregon Public Health Division
Environmental Health Assessment Program
Under Cooperative Agreement with the
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Agency Review

This document is being released for government agency partner review. The partner review period is an opportunity for our partnering government agencies to review this document for accuracy and readability. Neither this document nor any of the findings described therein should be shared with community members or potentially responsible parties. See dates on cover for partner review period.

Foreword

The Environmental Health Assessment Program (EHAP) within the Oregon Public Health Division (PHD) has prepared this Public Health Assessment under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services, Public Health Service. The mission of ATSDR is to serve the public by using the best science, taking responsive actions, and providing trusted health information to prevent harmful exposures and disease related exposures to toxic substances. This Public Health Assessment was prepared in accordance with ATSDR methodology and guidelines.

An ATSDR Public Health Assessment reviews available information about hazardous substances at a site and evaluates whether exposure to them might cause any harm to people. ATSDR conducts a Public Health Assessment for every site on or proposed for the National Priorities List (the NPL, also known as the Superfund list). A Public Health Assessment is not the same as a medical exam or a community health study.

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Introduction

The Environmental Health Assessment Program's (EHAP's) top priority is to ensure that the communities using the Portland Harbor Superfund Site Study Area have the best information possible to safeguard their health.

Under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), EHAP is federally mandated to evaluate the public health risks associated with coming into contact with chemical contaminants at Superfund sites located within the State of Oregon. EHAP is housed in the Oregon Department of Human Services Office of Environmental Public Health.

The Portland Harbor Superfund Site Study Area is a roughly 9-mile stretch of the Lower Willamette River starting in the north at the confluence with the Columbia River and ending near the Steel Bridge in downtown Portland, Oregon. Portland Harbor is an operational, industrial port that has been modified to accommodate ocean-going vessels. The landscape has been heavily modified for industrial and urban development.

Extensive contamination of Portland Harbor led to its listing as a Superfund Site in the year 2000. EHAP prepared a previous Public Health Assessment in 2006 that was focused on fish consumption as the primary way that chemicals from the site could be putting people's health at risk. That report and its findings are available online at http://www.atsdr.cdc.gov/HAC/pha/PortlandHarbor/PortlandHarborPHA032206.pdf. Briefly, eating more than the recommended amount of resident fish species from the Harbor was found to be a public health hazard, and EHAP continues to recommend that people heed the fish advisories in effect for Portland Harbor. The current fish advisory for Portland Harbor can be found at http://www.oregon.gov/DHS/ph/envtox/fishconsumption.shtml#Portland and states that:

- Women of childbearing age, particularly pregnant or breastfeeding women, children and people with weak immune systems, thyroid or liver problems, should avoid eating resident fish from Portland Harbor, especially carp, bass and catfish.
- Healthy women beyond childbearing age and healthy adult males should restrict the amount of resident fish eaten from Portland Harbor to no more than one 8-ounce meal per month.

This Public Health Assessment is focused on recreational users, anglers, and dockside workers who may be coming into contact with chemical

	contaminants through beach sediment, bottom sediment, and/or surface water. The federal Environmental Protection Agency (EPA) is the agency responsible for clean-up of the site and has provided EHAP with the data used in this report to assess the public health risks associated with the Portland Harbor Superfund Site.
Conclusions	EHAP reached three important conclusions in this Public Health Assessment:
Conclusion 1	EHAP concludes that swallowing and touching chemical contaminants in the water, beach sediment, and bottom sediment at the Portland Harbor Superfund Site is ***not*** expected to harm people's health.
Basis for Conclusion	The concentrations of chemicals measured in water, beach sediment, and bottom sediment are too low to harm the health of people who use the area for work, recreational, or fishing purposes. The concentrations of chemicals in water, beach sediment, and bottom sediment are also too low to harm the health of children who visit the site for recreational purposes.
Next Steps	EHAP recommends that the EPA and Responsible Parties continue efforts to clean-up sediments in the Portland Harbor Superfund Site that contribute to elevated chemical contaminant concentrations in fish.
Conclusion 2	Although not site-related, EHAP concludes that falling down steep embankments, potential collisions with large watercraft, entanglement or collision with underwater debris, and collisions with train and car traffic while recreating along the industrial and urban zones of the Portland Harbor Superfund Site area could physically injure people.
Basis for Conclusion	Physical hazards lining the industrial and urban zones of the Portland Harbor Superfund Site are well documented and include busy rail lines and roadways, steep embankments, heavy boat traffic, and underwater debris. All of these pose potential physical safety hazards to people using the Harbor recreationally.
Next Steps	EHAP recommends that recreational users and anglers: • Not trespass in industrial or other private properties along the Portland Harbor Superfund Site • Minimize time spent in the portions of the site that are navigable and/or heavily used by watercraft • Exercise caution when accessing the Willamette River in the Superfund area to avoid entanglement and collision with underwater debris and falling down steep embankments • Not cross railroad tracks except at designated "railroad crossing" locations
Conclusion 3	EHAP identified an additional hazard that is not specifically site-related. EHAP concludes that swallowing the water from combined sewer overflow (CSO) areas after a rain storm could cause bacteria-related illness.

Basis for Conclusion	The concentration of bacteria from sewage measured in the water in CSO areas following a rain storm could be high enough to cause bacteria-related illness in people who swallow small amounts of water while swimming or otherwise contacting water from the harbor. Call the City of Portland's Bureau of Environmental Services at 503-823-5328 for CSO locations. The CSO website is located at: http://www.portlandonline.com/bes/index.cfm?c=31030
Next Steps	We are taking the following actions: • EHAP will consult with the City of Portland to ensure that signs marking CSO locations and the hazards associated with swimming near CSO areas are well designed, well placed, and well maintained. • EHAP recommends that the City of Portland continue efforts to reduce the amount of sewage that spills into the Willamette River through CSOs. • EHAP recommends that people who use the Portland Harbor Superfund Site for work, recreation, or fishing: o Avoid swimming in or contacting the water from CSO areas following rain storms o Thoroughly wash hands after contacting water from the Lower Willamette River before eating o Thoroughly wash all body surfaces that come into contact with the water after swimming in or touching water from the Lower Willamette River. o Thoroughly wash any recreational equipment such as kayaks, oars, paddles, water skis etc. after use in the Lower Willamette River.
For More Information	Contact the Environmental Health Assessment Program in the Oregon State Office of Environmental Public Health: ehap.info@state.or.us 971-673-0440 1-877-290-6767 (if calling from outside the Portland Metro area)

Purpose and Health Issues

Under cooperative agreement with ATSDR, EHAP conducted this Public Health Assessment (PHA). EHAP and ATSDR are committed to providing a comprehensive assessment of potential health risks to communities who use Portland Harbor. This PHA evaluated the public health risks that recreational users, anglers, and dockside workers may face from having direct contact with beach sediment, river bottom (in-water) sediment, and surface water. ATSDR's mandate is to specifically assess the public health risks that may result from exposure to chemical contaminants and physical hazards. However, because bacterial contamination has also been well documented in the Portland Harbor Superfund Site, EHAP also evaluated health risks from contacting bacteria in the river water. Bacterial and physical hazards are the health issues of most concern to EHAP and for people who use the Portland Harbor Superfund Site for recreational, fishing, and work purposes.

Eating contaminated fish from the Harbor is the most significant health risk from chemical contamination at this site. EHAP did not address that issue directly in this report but has reiterated the important conclusions from a previous Public Health Assessment created by EHAP (then called SHINE), which was specifically focused on Portland Harbor fish consumption. The previous report found that eating resident fish species from the harbor is a public health hazard. This previous report can be found at http://www.atsdr.cdc.gov/HAC/pha/PortlandHarbor/PortlandHarborPHA032206.pdf [1].

Transients, who live outdoors along Portland Harbor, may come into contact with contaminants in ways not addressed in this report. It is unknown to what extent this population may come into contact with Portland Harbor contaminants, and what types of information or assistance they would find most useful. EHAP is in the process of evaluating whether an additional follow-up document addressing health risks specific to transients would be helpful to that population or those who serve them.

This report also does not address health risks associated with eating freshwater clams or mussels from Portland Harbor. This is because there is a very limited amount of clams and mussels within the harbor, and the people who may potentially be harvesting these foods are a very specific population. EHAP is in the process of evaluating whether a follow-up assessment specifically addressing health risks to those who may be eating freshwater clams and mussels from Portland Harbor would be helpful.

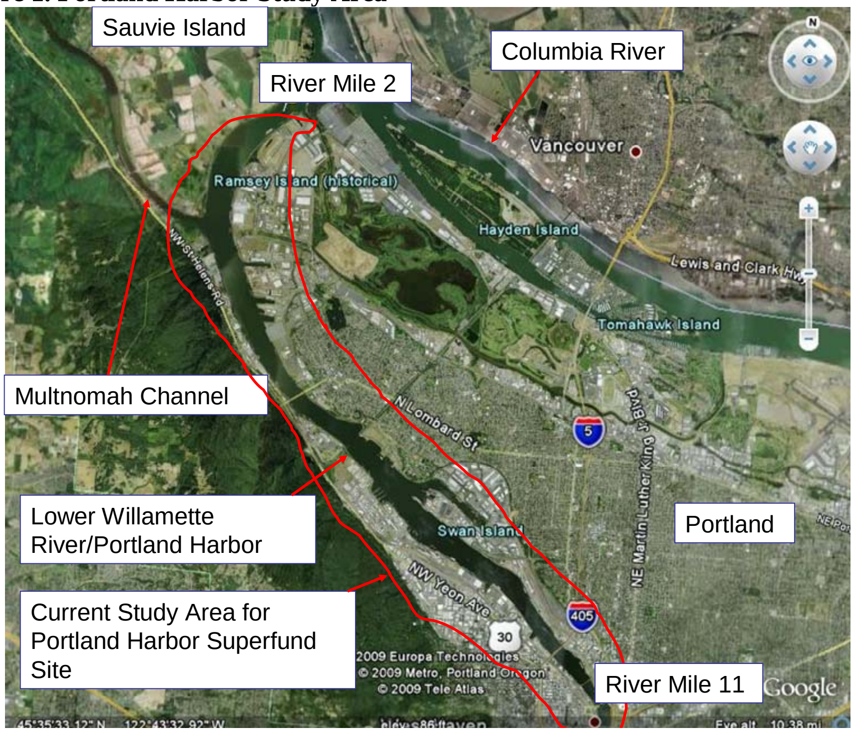
Background

Site Description

Portland Harbor is located in Multnomah County, Oregon, situated along the east and west banks of the Lower Willamette River. On December 1, 2000, a portion of Portland Harbor was listed on the National Priorities List (NPL). The initial study area for the site was a nearly six-mile stretch of the Willamette River, from the southern tip of Sauvie Island [river mile 3.5] to Swan Island [river mile 9.2]. The study area has since been expanded, and the current study area extends from river mile 2 to river mile 11 and includes the first upper mile of Multnomah Channel (Figure 1). The portion of the river that was placed on the NPL is the most industrialized area of the Willamette River and lies entirely within the city limits of Portland, Oregon.

The Willamette River begins in the Cascade Mountains and flows generally north to its confluence with the Columbia River [2]. The last 26.5 miles of the Willamette River before the confluence is wide and slow moving and affected by tidal reversals resulting in daily fluctuations in water levels. This section of the river was generally shallow historically, but the last 12 miles of the Willamette River has an average depth of 45 feet with a maximum of 140 feet. This greater depth is the result of regular dredging by the U.S. Army Corps of Engineers to allow large ocean-going ships to use Portland Harbor. The portion from river miles 3 to 10 is where most of the sediment from further upstream in the Willamette River accumulates.

Figure 1. Portland Harbor Study Area



Site History

In 2002, ATSDR identified consumption of contaminated fish from the Portland Harbor site as the main way people's health could be put at risk from site contaminants. This was documented in their initial public health assessment (PHA) in 2002 [3]. Under a cooperative agreement with ATSDR, EHAP (then called SHINE) evaluated the public health impact of eating fish from Portland Harbor in an additional PHA released on March 22, 2006 [1].

Commercial and industrial activities are an integral part of Portland Harbor. Past and present sources of pollution have contaminated the area with metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, dioxins/furans, petroleum products and other pollutants in the beach and river bottom sediment as well as the surface water. A group of potentially responsible parties, known as the Lower Willamette Group (LWG), has funded the majority of the remedial investigation/feasibility study to address these contaminants.

The EPA and the Oregon Department of Environmental Quality (ODEQ) jointly manage the cleanup of the Portland Harbor NPL Site. EPA has the primary responsibility for the in-water portion and ODEQ for the upland sources of contamination. These two agencies are also working closely with nine natural resource trustees. The trustees are designated by law to act on behalf of the public or tribes to protect and manage natural resources, such as land, air, water, fish, and wildlife. Among the trustees are five tribes - the Confederated Tribes of the Grand Ronde (CTGR), Confederated Tribes of Siletz Indians (CTSI), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Confederated

Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe. The Oregon Department of Fish and Wildlife (ODFW), the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Fish and Wildlife Service (USFWS) are state and federal government natural resource trustees.

Site Visit

EHAP and ATSDR staff have visited Portland Harbor numerous times between 2002 and 2007 by boat, car and foot. EHAP staff have interviewed numerous individuals about fishing access, transient (homeless) camp locations, recreational sites and activities, fish and meal preference, fish consumption and preparation practices and other aspects relevant to this and previous assessments. EHAP has toured Portland Harbor by boat with Willamette Riverkeepers, Multnomah County Vector Control, EPA Region 10, and ODEQ.

Demographics

ATSDR's public health assessments usually have a section where the demographic characteristics of the population within a mile of the site are described. This is done because it is assumed that the population living near a site will have the highest risks of coming into contact with site contaminants. However at the Portland Harbor site, the individuals most at risk are those who recreate and work on and along the Willamette River. These recreational users and dockside workers appear to be made up of people from specific hobby, interest, and employment groups and not simply those living near the river. Therefore, the usual demographic evaluation will not be done in this document. Instead there will be descriptions of these "at risk" groups in relevant sections of this PHA. In addition to recreational users, many transient camps have been observed along the banks of Portland Harbor; however, it is difficult to obtain information on this population.

Land and Water Use

The habitat from river miles 2 to 11 (the current Portland Harbor site study area) has been substantially altered to accommodate urban development and an extensive shipping industry [4]. Shoreline features include steeply sloped banks covered with riprap or constructed bulkheads, with manmade structures such as piers and wharves extending out over the water. This area of the river is largely devoid of trees and other vegetation along the riverbanks.

The habitat of the rest of the lower Willamette River is not as degraded as the initial study area. This is indicated by the gently sloping, well-vegetated banks at Ross Island, the mouth of Stephens Creek, Powers Marine Park, the mouth and lower reaches of Johnson Creek, Multnomah Channel, Kelly Point Park, and the lower reaches of the Columbia Slough. The first four locations are upstream and the last three are downstream of the current Portland Harbor site study area.

The site area is heavily industrialized. Some of the historical or current industrial operations along Portland Harbor include: marine construction, bulk petroleum product storage and handling, construction material manufacturing, oil gasification plant operations, pesticide/herbicide manufacturing, agricultural chemical production, battery processing, liquid natural gas plant operations, ship maintenance, repair, and refueling, barge/rail car manufacturing and metal scrapping and recycling. Within or near the initial Portland Harbor study area, there are numerous active investigations or cleanups being performed under oversight by ODEQ including the investigation of several City of Portland outfalls.

Residential areas are intermixed with these riverside industries or are close by, and include the St. John's neighborhood, Overlook Park, and the communities of Linnton and University Park. In addition, the Lower Willamette River is used for recreational fishing, boating, swimming, and water skiing. Cathedral Park and Swan Island serve as boat launches and bank fishing locations (observed during site visits). During all of our site tours, we observed tents and makeshift dwellings, which provided evidence of people living along the riverbanks.

Discussion

This section explains the assessment process that EHAP used to develop conclusions about how contaminants at the Portland Harbor Superfund Site may affect the public's health. It includes a description of the sources of information that EHAP used and how that information was combined and analyzed. This section also presents, in detail, the rationale behind each of the conclusions of this PHA.

Data Use and Sampling Methods

In order to understand whether or not contaminants at the Portland Harbor Superfund Site pose a risk to recreational users and workers, it is important to know the concentration of contaminants in various "media" (beach sediment, in-water (river bottom) sediment, and surface water). This information is gathered by collecting samples of the environmental media from areas where people come into contact with them and measuring the amount of various contaminants within those samples.

Environmental sampling data included in this report are from the Comprehensive Round 2 Report prepared by the Lower Willamette Group under the direction of the EPA [5]. The EPA collected samples throughout the 9-mile length of the current study area from 2002-2005.

The EPA used approved laboratory standards and methods to measure the concentration of chemicals in the environmental samples. EHAP believes that the sampling data were of adequate quality to evaluate risk and make public health decisions.

Nature and Extent of Contamination

The EPA chose specific chemicals to be measured in the collected samples based on the types of chemicals historically and currently used at industrial sites along the harbor. The EPA also measured chemicals that are commonly found in urban areas and at other hazardous waste sites. These chemicals included metals, such as lead, mercury, and arsenic; organic chemicals, such as PCBs; and pesticides. The complete list of chemicals measured in the three media (beach sediment, in-water sediment, and surface water) can be found in the Tables B1-B4 in Appendix B.

EHAP compared the maximum concentrations for each chemical measured against a standard comparison value (CV). EHAP used CVs from a variety of sources including ATSDR and the EPA. These comparison values are media-specific and represent the concentration of a given contaminant in a given medium that scientists believe people could contact every day for their entire lives without any health problems. Because most people will not contact those media that often, these CVs are very protective of health. See Appendix A for more detailed explanations and definitions of the CVs used.

When the concentration of a contaminant in a medium (beach sediment, in-water sediment, or surface water) was higher than the CV for that contaminant, it became a "contaminant of potential concern" or COPC. It is important to remember that CVs are very protective of health, so it does not necessarily mean that people will become ill if they come into contact with a COPC at Portland Harbor. It just means that these contaminants were looked at more closely in the next stage of the assessment. When the concentration of a contaminant in a medium (beach sediment, in-water sediment, or surface water) was lower than the comparison value for that contaminant, EHAP concluded that people's health could not be affected by contacting that contaminant in that medium and those contaminants were not evaluated further in the assessment.

EHAP categorized the beaches at Portland Harbor into those accessed by recreational users (”recreational beaches”) and those accessible only to employees of industrial properties along the harbor ("industrial beaches", also labeled as "dockside worker" on maps). See Figure 2 for the locations of recreational and industrial beaches that the EPA sampled for contaminants.

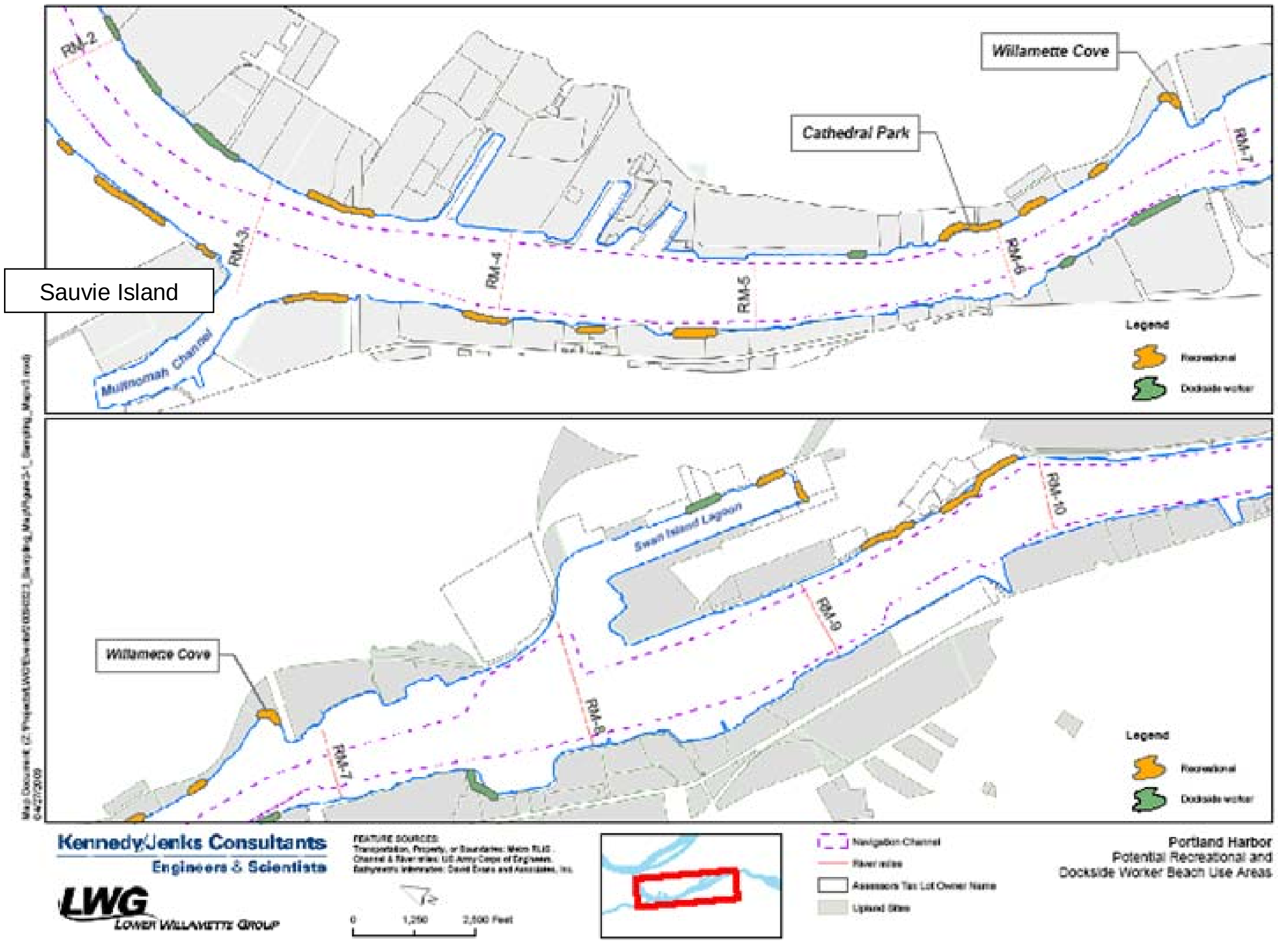


Figure 2. Dockside worker (industrial) and recreational beach sampling locations

The COPCs identified for recreational beach sediment included copper and five polycyclic aromatic hydrocarbons (PAHs). These five PAHs are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The recreational beach with the highest concentrations of PAHs in the sediment was on Sauvie Island on the west bank of the Willamette at approximately river mile 2.5 (See Figure 2 top panel). The recreational beach with the highest concentration of copper found in the beach sediment was located just south of Cathedral Park on the same side of the river (Figure 2 top panel).

The COPCs identified for industrial beach sediment included the same five PAHs as in recreational beach sediment above plus one more: benzo(k)fluoranthene. Copper was not a COPC for industrial beach sediment. The industrial beach with the highest levels of PAH contamination in the sediments is just south of river mile 6 on the west side of the river.

EHAP identified 19 COPCs for in-water sediment. These included 2 metals (arsenic and lead); 6 PAHs; bis(2-ethylhexyl)phthalate; pentachlorophenol; 3 groupings of PCBs; dioxin; and 5 pesticides.

For surface (river) water, arsenic was the only COPC that EHAP identified. See Table 1 for a comprehensive list of COPCs identified for all media at the Portland Harbor Superfund Site.

Table 1. Contaminants of Potential Concern (COPCs) in All Media at Portland Harbor

Class of Chemical	Contaminant of Potential Concern	Recreational Beach Sediment	Industrial Beach Sediment	In-Water Sediment	Surface Water
Metals	Arsenic			X	X
	Lead			X	
	Copper	X			
Polycyclic Aromatic Hydrocarbons (PAHs)	Benzo(a)anthracene	X	X	X	
	Benzo(a)pyrene	X	X	X	
	Benzo(b)fluoranthene	X	X	X	
	Benzo(k)fluoranthene		X	X	
	Dibenzo(a,h)anthracene	X	X	X	
	Indeno(1,2,3-cd)pyrene	X	X	X	
Phthalates	Bis(2-ethylhexyl) phthalate			X	
Phenols	Pentachlorophenol			X	
Polychlorinated Biphenyls (PCBs)	Total PCB Aroclors			X	
	Total PCB Congeners			X	
	Total PCBs without dioxin-like congeners			X	
Dioxins	Total Dioxin TEQ*			X	
Pesticides	Aldrin			X	
	Dieldrin			X	
	Total DDDs			X	
	Total DDEs			X	
	Total DDTs			X	

*TEQ = Toxic Equivalency refers to the sum of the toxicity of all of the various dioxin and dioxin-like compounds relative to the most toxic member of the dioxin family: 2,3,7,8-tetrachlorodibenzo-p-dioxin.

Exposure Pathways

In order for a chemical contaminant to harm a person's health, there must be a way for a person to come into contact with a chemical. An exposure pathway describes the way that a chemical moves from its source to physical contact with a person. An exposure pathway has 5 elements:

1) A contaminant source or release
2) A way for the chemical to move through the environment to a place where people could come into contact with it
3) A place where people could contact the contaminant
4) Route of exposure to a contaminant (breathing it, swallowing it, absorbing it through skin, etc.)
5) A population that comes in contact with the contaminant

An exposure pathway is called “completed” if all 5 of the elements are known to be in place and occurring. If it is unknown whether one or more of the elements is in place, then it is called a “potential” pathway. If it is known that one of the 5 elements is not in place, then that pathway is “eliminated.”

<u>Completed Pathways</u>
Table 2 summarizes the completed exposure pathways that EHAP identified for the Portland Harbor Superfund Site.

Table 2. Completed exposure pathways

Pathway	Time	Source	Media and Transport	Point of Exposure	Route of Exposure	Exposed Population
Contact with beach sediment	Past, present, future	Industrial and municipal discharges	Beach sediment	Parks and shoreline access areas	Swallowing, touching the skin	Recreational beach users, anglers, transient users, dockside workers
Contact with surface water	Past, Present, Future	Industrial and municipal discharges	Surface water	River	Swallowing, touching the skin	Recreational swimmers, anglers, transient users, and occupational divers
Contact with in-water sediment	Past, Present, Future	Industrial and municipal discharges	In-water sediment	River	Swallowing, touching the skin	Anglers, occupational divers
Fish consumption	Past, Present, Future	Industrial and municipal discharges	Fish tissue	River	Eating	Anglers and their families

While transient users and occupational divers were identified as exposed populations in the exposure pathway analysis, their risks were not evaluated in this document. Transient users come into contact with media at Portland Harbor much more frequently, but not usually for as long of a period of time, as other users. EHAP assumed that transient users have higher exposures than recreational users, but over shorter periods of time. Because of the unique exposure pathways of transient users, EHAP will do a community needs assessment to find out whether a separate document would be helpful or necessary for the transient population using Portland Harbor. Therefore, transient user exposure scenarios will not be further addressed in this Public Health Assessment.

Occupational divers come into contact with bottom sediment much less frequently than avid anglers but in potentially larger quantities. EHAP assumed that the assessment for anglers' contact with bottom sediment would also address the risks to occupational divers. Therefore, occupational divers were not specifically addressed in this Public Health Assessment.

The fish consumption pathway for anglers and their families was thoroughly assessed in a previous Public Health Assessment [1] and will not be addressed in this document.

In this PHA, EHAP assessed the completed exposure pathways for recreational users (children ages 1-6 were assessed separately from adults), for anglers exposed to in-water sediment while fishing, and for dockside workers exposed to industrial beach sediment.

Children ages 1-6 represent a vulnerable, sensitive population, so assessing the health risks to them is protective of the most sensitive adult populations. Dockside workers may come into contact with beach sediment that recreational users and children may not encounter, so EHAP addressed the potential health risks to these workers. And lastly, the exposure pathway for anglers who fish the harbor, either from boats or from the shore, was assessed because these people may also come into frequent contact with in-water sediment.

Potential Pathways

Table 3 summarizes the potential pathways identified for the Portland Harbor Superfund Site. The pathways listed in Table 3 are labeled as potential pathways because it is unknown whether or not there are people who are actually exposed.

Table 3. Potential exposure pathways

Pathway	Time	Source	Media and Transport	Point of Exposure	Route of Exposure	Exposed Population
Clam/ Mussel consumption	Past, Present, Future	Industrial and municipal discharges	Clam/ Mussel tissue	River	Eating	Unknown (Possibly Tribal, transient, and ethnic populations)
Contact with groundwater	Past, Present, Future	Industrial and municipal discharges	Groundwater	River-side seeps and springs	Drinking	Unknown (Possibly transient groups)

It is unknown whether anyone is actually eating clams and mussels from Portland Harbor. It is illegal to collect freshwater clams from anywhere in Oregon, including Portland Harbor. If the need arises, EHAP will do an evaluation of health risks from eating clams and mussels from the Portland Harbor Superfund Site in a separate Health Consultation document. This pathway will not be addressed in this Public Health Assessment.

It is also unknown whether anyone is drinking water from groundwater seeps and springs along the sides of Portland Harbor. It is possible that transient users may drink this water.

EHAP will conduct a needs assessment to find out whether or not a separate document specifically addressing the risks to transients along Portland Harbor would be useful. This pathway will not be addressed in this Public Health Assessment.

Eliminated Pathways

No eliminated pathways were identified for the Portland Harbor Superfund Site.

Public Health Implications

As described in the previous section, EHAP assessed the completed exposure pathways of COPCs to three groups of people: Recreational users contacting recreational beach sediment and surface water with special consideration of young children; anglers contacting in-water sediment and surface water; and dockside workers contacting industrial beach sediment. The following section describes the contaminant doses and public health implications for people in each scenario separately, along with an explanation of the general process of dose calculation and how those calculated doses are used. Dose calculations are used to estimate whether or not contaminants from Portland Harbor are likely to harm people's health. Appendix C describes this process in more detail.

Dose Calculation

People can potentially be exposed to contaminants from Portland Harbor in multiple media. For example, a child playing on a beach may contact arsenic in the beach sediment and also in the water. Therefore, it is most protective of health to add the calculated dose of each COPC for each medium (i.e., water and beach sediment) to get a total dose, even though arsenic was only identified as a COPC in water during the screening process.

Dose calculation requires some assumptions about the frequency and intensity with which people contact contaminants from the Portland Harbor Superfund Site. Wherever possible, EHAP used site-specific information, but when site-specific information was unavailable, default values established by ATSDR or the EPA were used. Where default values were unavailable, EHAP used best professional judgment. For the complete list of exposure assumptions used to calculate doses in this report, see Appendix C. Appendix C also contains details about the methods used to calculate doses of COPCs.

Non-Cancer

To evaluate the risk of any health outcome other than cancer, calculated doses were compared against health guidelines (Tables 4 and 6). A health guideline is the daily dose of a chemical that scientists consider unlikely to harm people's health. EHAP followed ATSDR guidance [6] by using the health guidelines established by ATSDR, called Minimal Risk Levels (MRLs), whenever available. ATSDR develops MRLs for acute (14 days or less), intermediate (between 15 and 364 days), and chronic (1 or more years) exposure durations. Because exposures at the Portland Harbor Superfund Site are likely to be over the long term, chronic MRLs are most appropriate. When a specific chemical did not have a chronic MRL, it was substituted with the intermediate MRL. When neither a chronic nor an intermediate MRL was available, EHAP used an oral reference dose (RfD) established by the EPA.

EHAP divided calculated doses by the health guideline. The resulting number is called the Hazard Quotient (HQ). If the HQ was greater than 1 for a contaminant in any given scenario, that COPC was upgraded to a contaminant of concern (COC). Identification as a COC does not mean that people's health will be harmed, but the identified contaminant was moved through to the final step of the analysis.

Cancer

EHAP calculated the lifetime risk of developing cancer from exposure to COPCs at the Portland Harbor Superfund Site for people in the 3 exposure scenarios described above (Tables 5 and 7 through 10). Cancer risk is the product of the calculated dose multiplied by a Cancer Slope Factor (CSF) developed by the EPA. The summed cancer risks from each cancer-causing COPC give an overall cancer risk for people in each scenario.

Cancer risk is expressed in terms of additional cancer cases in a theoretical population where everyone in that population would get the same dose of a chemical every day over their entire lifetime. For example, EHAP considers 1 additional case of cancer out of 10,000 (1E-04) people exposed every day for an entire lifetime to be a low risk. A cancer risk of 1 additional case out of 100,000 people (1E-05) would be a very low risk and a cancer risk of 1 additional case out of 1,000,000 people (1E-06) would be an insignificant risk. When a cancer risk for a COPC was greater than 1E-04, EHAP upgraded that COPC to a COC. Identification as a COC does not mean that increased cancer risk is expected, but that further analysis is needed.

Exposure Scenario 1: Recreational Users

In calculating the doses, EHAP assumed that children and adults would swim in the water of Portland Harbor where they could accidentally swallow some water and also have full-body skin contact with contaminants in the water. It was also assumed that adults and children would have skin contact with beach sediment and accidentally swallow some of the beach sediment. Appendix C describes all of the assumptions used in the dose calculation in greater detail.

EHAP calculated doses of COPCs to recreational users using the maximum COPC concentrations found at the Portland Harbor Site for beach sediment and surface water. Using site-wide maximum contaminant concentrations is very protective of the public's health because it assumes that a person would spend all of their time at the harbor in contact with the most contaminated sediment/surface water in the entire 9-mile Superfund site. In reality, people are more likely to visit different areas of the site, often contacting sediments/surface water with lower concentrations of contaminants than the maximums. However, using site-wide maximums to calculate dose is especially appropriate for beach sediments because beaches were sampled as composites. This means that several samples (twelve in the case of the Round 2 Report) of beach soil were combined into one sample for each of the 15 recreational beaches sampled (See Figure 2 for recreational beaches). So, the maximum contaminant concentration in beach sediment for the site represents an entire recreational beach area. Using the site-wide maximum concentrations is like creating a hypothetical “worst-case scenario” beach that had the highest concentration for all of the contaminants measured. This practice protects the health of an individual or family, who may have a favorite beach.

Table 4. Doses and Non-Cancer Risk to Adult Recreational Users

Chemical	Total Dose (mg/kg/day)	MRL (mg/kg/day)	MRL type	Hazard Quotient	Contaminant of Concern (Y/N)
Arsenic	0.0000054	0.00003	Chronic MRL	0.18	N
Copper	0.00022	0.01	Intermediate MRL	0.022	N
Benzo(a)anthracene	2.8E-07	---		---	N
Benzo(a)pyrene	4.1E-07	---		---	N
Benzo(b)fluoranthene	3.4E-07	---		---	N
Dibenzo(a,h)anthracene	3.9E-08	---		---	N
Indeno(1,2,3-cd)pyrene	3.2E-07	---		---	N

Note: Numbers rounded to two significant digits
Mg/kg/day = Milligrams of chemical per kilogram of body weight per day
MRL = Minimal Risk Level
“---“ = No MRL or RfD has been developed for these PAHs [7].

Table 5. Cancer Risk for Adult Recreational Users

Chemical	Total Cancer Dose (mg/kg/day)	Cancer Slope Factor (1/mg/kg/day)	Cancer Risk	Contaminant of Concern (Y/N)
Arsenic	2.3E-06	5.7†	1.3E-05	N
Copper*	9.6E-05	---	---	N
Benzo(a)anthracene	1.2E-07	0.73	8.7E-08	N
Benzo(a)pyrene	1.8E-07	7.3	1.3E-06	N
Benzo(b)fluoranthene	1.5E-07	0.73	1.1E-07	N
Dibenzo(a,h)anthracene	1.7E-08	7.3	1.2E-07	N
Indeno(1,2,3-cd)pyrene	1.4E-07	0.73	1.0E-07	N
Total Cancer Risk	---	---	1.5E-05	N

Note: Numbers rounded to two significant digits
Mg/kg/day = Milligrams of chemical per kilogram of body weight per day
† This cancer slope factor incorporates more recent studies than the 1.5 mg/kg/day^{-1} cancer slope factor in EPA’s IRIS database [8, 9].
* Copper does not cause cancer [10].

The PAHs without MRLs or RfDs for comparison (Table 4) can have acute non-cancer health effects, but these occur at doses much higher than those estimated for this site. Benzo(a)pyrene, the most toxic of the 5 PAHs in Tables 4 and 5, did not cause any observable health problems in pregnant animals or their babies even at 10 mg/kg/day; this dose is 4 million times higher than any PAH dose estimated at Portland Harbor for adult recreational users [7]. The most sensitive health outcome for PAHs is cancer.

None of the calculated doses were higher than their MRL (Table 4), and the overall cancer risk for adult recreational users was less than 1E-04 (Table 5). Therefore, no COCs were identified for adult recreational users, and EHAP does not expect that any chemicals measured at the Portland Harbor Superfund Site will harm the health of adult recreational users.

Table 6. Dose and Non-Cancer Risk to Children (1-6 years old) Recreational Users

Chemical	Total Dose (mg/kg/day)	MRL (mg/kg/day)	MRL type	Hazard Quotient	Contaminant of Concern (Y/N)
Arsenic	0.000066	0.00003	Chronic MRL	2.2	Y
Copper	0.002	0.01	Intermediate MRL	0.2	N
Benzo(a)anthracene	3.9E-06	---		---	N
Benzo(a)pyrene	6.5E-06	---		---	N
Benzo(b)fluoranthene	5.5E-06	---		---	N
Dibenzo(a,h)anthracene	6.0E-07	---		---	N
Indeno(1,2,3-cd)pyrene	5.0E-06	---		---	N

Note: Numbers rounded to two significant digits
Mg/kg/day = Milligrams of chemical per kilogram of body weight per day
MRL = Minimal Risk Level
"---" = No MRL or RfD has been developed for these PAHs [7].

Table 7. Cancer Risk to Children (1-6 years old) Recreational Users

Chemical	Total Cancer Dose (mg/kg/day)	Cancer Slope Factor (1/mg/kg/day)	Cancer Risk	Contaminant of Concern (Y/N)
Arsenic	5.6E-06	5.7†	3.2E-05	N
Copper*	0.00017	---	---	N
Benzo(a)anthracene	3.4E-07	0.73	2.5E-07	N
Benzo(a)pyrene	5.5E-07	7.3	4.0E-06	N
Benzo(b)fluoranthene	4.7E-07	0.73	3.5E-07	N
Dibenzo(a,h)anthracene	5.1E-08	7.3	3.8E-07	N
Indeno(1,2,3-cd)pyrene	4.3E-07	0.73	3.2E-07	N
Total Cancer Risk	---	---	3.7E-05	N

Note: Numbers rounded to two significant digits
Mg/kg/day = Milligrams of chemical per kilogram of body weight per day
† This cancer slope factor incorporates more recent studies than the 1.5 mg/kg/day^{-1} cancer slope factor in EPA's IRIS database [8, 9].
* Copper does not cause cancer [10].

The calculated dose of arsenic exceeded the MRL for children (Table 6). However, MRLs are developed with many safety factors. The calculated dose, 0.000066 mg/kg/day is still 65 times lower than any dose (0.0043 mg/kg/day) that has been shown to harm people's health in ways other than causing cancer [11, 12].

The PAHs without MRLs or RfDs for comparison (Table 6) can have acute non-cancer health effects, but these occur at doses much higher than those estimated for child recreational users of Portland Harbor. Benzo(a)pyrene, the most toxic of the 5 PAHs in Tables 6 and 7, did not cause any observable health problems in pregnant animals or their babies even at 10 mg/kg/day; this dose is 650,000 times higher than any PAH doses estimated at Portland Harbor for child recreational users [7]. The most sensitive health outcome for PAHs is cancer.

None of the calculated doses were higher than their MRL (Table 6), and the overall cancer risk for adult recreational users was less than 1E-04 (Table 7). EHAP does not expect that any of the chemicals measured at the Portland Harbor Superfund Site will harm the health of children who use the area recreationally.

Exposure Scenario 2: Anglers

To calculate doses of COPCs for anglers, EHAP assumed that all persons would be adults who contact surface water and in-water sediment. EHAP assumed that anglers only contact in-water sediment about a quarter of the time they are fishing. Anglers do, of course, come into contact with beach sediments as well, but EHAP assumed that the adult recreational user scenario adequately addressed all the types of exposure to beach sediment that an angler would have. As discussed in the Exposure Pathway section, anglers also contact contaminants by eating the fish they catch. COPC doses from eating fish are not included in the total doses calculated here because that exposure pathway has already been addressed in great detail in a previous Public Health Assessment [1].

There were 19 COPCs identified in in-water sediment and in surface water (See Table 1). Initially, doses for all COPCs were calculated using site-wide maximum contaminant concentrations for surface water and in-water sediment (See Tables 8 and 9). This is very protective of public health because it assumes that anglers spend 100% of their time at the Portland Harbor Superfund Site in contact with the most highly contaminated surface water and in-water sediment in the entire 9-mile length of river. These doses were then screened against health guidelines (Table 8) and cancer risks were calculated (Table 9).

Table 8. Dose and Non-Cancer Health Risks to Anglers Based on Site-Wide Maximum COPC Concentrations

Chemical	Total Dose (mg/kg/day)	MRL (mg/kg/day)	MRL type	Hazard Quotient	Contaminant of Concern (Y/N)
Arsenic	8.1E-06	0.00003	MRL	0.27	N
Lead†	---	---		---	N
Benzo(a)anthracene	2.5E-05	---		---	N
Benzo(a)pyrene	2.9E-05	---		---	N
Benzo(b)fluoranthene	2.7E-05	---		---	N
Benzo(k)fluoranthene	1.4E-05	---		---	N
Dibenzo(a,h)anthracene	2.9E-06	---		---	N
Indeno(1,2,3-cd)pyrene	2.1E-05	---		---	N
Bis(2-ethylhexyl) phthalate	3.4E-05	0.06	chr. MRL	0.00056	N
Pentachlorophenol	2.7E-06	0.001	chr. MRL	0.0027	N
Total PCB Aroclors	6.6E-06	0.00002	chr. MRL	0.33	N
Total PCB Congeners	7.6E-06	0.00002	chr. MRL	0.38	N
Total PCBs without dioxin-like congeners	7.5E-06	0.00002	chr. MRL	0.38	N
Total Dioxin TEQ1	1.8E-09	1.00E-09	chr. MRL	1.8	Y
Aldrin	5.3E-08	0.00003	chr. MRL	0.0018	N
Dieldrin	2.7E-08	0.00005	chr. MRL	0.00054	N
Total DDDs	3.2E-07	0.0005	int. MRL	0.00065	N
Total DDEs	2.7E-07	0.0005	int. MRL	0.00054	N
Total DDTs	1.3E-06	0.0005	int. MRL	0.0027	N

Note: Numbers rounded to two significant digits
Mg/kg/day = Milligrams of chemical per kilogram of body weight per day
MRL = Minimal Risk Level
Chr. = Chronic exposure is considered 1 year or longer.
Int. = Intermediate exposure is considered between 15 and 364 days.
"---" = No MRL or RfD has been developed for these PAHs [7].
†While lead was one of the 19 COPCs for angler exposure to in-water sediment, the process for calculating lead dose and evaluating the health risk for lead is different from all of the other 18 COPCs. Appendix D describes in detail the process of dose and risk calculation and analysis for lead.

Note that while the HQ for total dioxin TEQ[1] was 1.8 (See Table 8), the calculated dose was still 67 times lower than any dose that has been shown to harm the health of experimental animals [13, 14]. Therefore, EHAP concluded that the more significant concern for total dioxin TEQ was based on cancer risk. The non-cancer health

[1] See Appendix E for definition of total dioxin TEQ and related health information.

implications of total dioxin TEQ were not evaluated further because EHAP does not expect anyone's health to be harmed by this contaminant in ways not addressed in the cancer assessment (See Tables 9 and 10).

Similarly, The PAHs without MRLs or RfDs for comparison (Table 8) can have acute non-cancer health effects, but these occur at doses much higher than those estimated for anglers at Portland Harbor. Benzo(a)pyrene, the most toxic of the 6 PAHs in Tables 8-10, did not cause any observable health problems in pregnant animals or their babies even at 10 mg/kg/day; this dose is 29,000 times higher than any PAH doses estimated at Portland Harbor for anglers [7].

Table 9. Cancer Risk to Anglers Based on Site-Wide Maximum COPC Concentrations

Chemical	Total Dose (mg/kg/day)	Cancer Slope Factor (1/mg/kg/day)	Cancer Risk	Contaminant of Concern (Y/N)
Arsenic	3.5E-06	5.7†	2.0E-05	Y
Lead*	---	---	---	N
Benzo(a)anthracene	1.1E-05	0.73	7.7E-06	N
Benzo(a)pyrene	1.2E-05	7.3	9.0E-05	Y
Benzo(b)fluoranthene	1.1E-05	0.73	8.3E-06	N
Benzo(k)fluoranthene	5.9E-06	0.073	4.3E-07	N
Dibenzo(a,h)anthracene	1.2E-06	7.3	9.0E-06	N
Indeno(1,2,3-cd)pyrene	8.8E-06	0.73	6.4E-06	N
Bis(2-ethylhexyl) phthalate	1.4E-05	0.014	2.0E-07	N
Pentachlorophenol	1.2E-06	0.12	1.4E-07	N
Total PCB Aroclors	2.8E-06	2	5.7E-06	N
Total PCB Congeners	3.3E-06	2	6.5E-06	N
Total PCBs without dioxin-like congeners	3.2E-06	2	6.5E-06	N
Total Dioxin TEQ	7.5E-10	1.50E+05	1.1E-04	Y
Aldrin	2.3E-08	17	3.8E-07	N
Dieldrin	1.2E-08	16	1.9E-07	N
Total DDDs	1.4E-07	0.24	3.3E-08	N
Total DDEs	1.2E-07	0.34	3.9E-08	N
Total DDTs	5.7E-07	0.34	1.9E-07	N
Total Cancer Risk			**2.7E-04**	**Y**

Note: Numbers rounded to two significant digits
Mg/kg/day = Milligrams of chemical per kilogram of body weight per day
† This cancer slope factor incorporates more recent studies than the 1.5 $mg/kg/day^{-1}$ cancer slope factor in EPA's IRIS database [8, 9].
*While lead was one of the 19 COPCs for angler exposure to in-water sediment, the process for calculating lead dose and evaluating the health risk for lead is different from all of the other 18 COPCs. Appendix D describes in detail the process of dose and risk calculation and analysis for lead.

The overall cancer risk to anglers based on site-wide maximum COPC concentrations is 2.7E-04 (See Table 9). This is equivalent to 2.7 additional cancer cases out of 10,000 people that would have the same exposure over their entire lives. This is in the range of increased cancer risk that EHAP considers to be between a low and a moderate risk. The major contributors to this overall cancer risk (See Table 9) are arsenic (2.0E-05); the PAH Benzo(a)pyrene (9.0E-05); and the total Dioxin TEQ (1.1E-04), a sum of all dioxins based on their toxicity relative to 2,3,7,8-tetrachlorodibenzo-p-dioxin. See Appendix E for more information about these three contaminants and related health information.

As stated before, using site-wide maximum COPC concentrations to calculate doses is very protective of health and greatly overestimates dose and risk. In order for these calculations to be accurate, an angler would have to fish 156 days/year and always fish in the exact spot within the 9-mile Superfund site study area where the maximum concentration of each of these contaminants was measured. It is much more likely that an angler will cover a larger area while fishing, coming into contact with in-water sediments from areas scattered around a mile or half-mile stretch of the river. Therefore, a more realistic way to calculate dose is to use average COPC concentrations within smaller areas of the site.

In-water sediment has the most significant contribution to the estimated doses, with surface water only contributing an insignificant portion (See Table C10 in Appendix C). Therefore, EHAP recalculated four sets of doses based on site-wide maximums in surface water but area-specific averages for in-water sediment for arsenic, benzo(a)pyrene, and total dioxin TEQ. The following area-specific averages were chosen based on the areas that had the highest levels of contamination for each of the 3 remaining COPCs: river mile 6 west (highest area average for benzo(a)pyrene), river mile 7 east (highest area average for arsenic), and river mile 7 west (highest area average for total dioxin TEQ). The site-wide averages for these contaminants are shown as a reference; these recalculated doses were then use to calculate cancer risks for each contaminant and overall cancer risk for each area. These data are presented in Table 10.

Table 10. Cancer Risk to Anglers

River Mile Area	Chemical	Total Cancer Dose (mg/kg/day)	Cancer Slope Factor 1/mg/kg/day	Cancer Risk
RM 6 West	Arsenic	2.1E-07	5.7†	1.2E-06
	Benzo(a)pyrene^	2.6E-06	7.3	1.9E-05
	Total Dioxin TEQ	1.5E-12	1.50E+05	2.2E-07
	Total Cancer Risk	---	---	**2.0E-05**
RM 7 West	Arsenic	2.3E-07	5.7†	1.3E-06
	Benzo(a)pyrene	4.9E-08	7.3	3.5E-07
	Total Dioxin TEQ^	9.99E-11	1.50E+05	1.5E-05
	Total Cancer Risk	---	---	**1.7E-05**
RM 7 East	Arsenic^	5.5E-07	5.7†	3.1E-06
	Benzo(a)pyrene	2.0E-08	7.3	1.5E-07
	Total Dioxin TEQ	3.0E-12	1.50E+05	4.5E-07
	Total Cancer Risk	---	---	**3.7E-06**
Site-wide	Arsenic	2.6E-07	5.7†	1.5E-06
	Benzo(a)pyrene	1.5E-07	7.3	1.1E-06
	Total Dioxin TEQ	8.9E-12	1.50E+05	1.3E-06
	Total Cancer Risk	---	---	**3.9E-06**

Note: Numbers rounded to two significant digits
^Contaminant with highest area average
Mg/kg/day = Milligrams of chemical per kilogram of body weight per day
RM = River Mile
† This cancer slope factor incorporates more recent studies than the 1.5 mg/kg/day^{-1} cancer slope factor in EPA's IRIS database [8, 9].

None of the overall or chemical-specific cancer risks were greater than 1E-04. EHAP does not expect any increased risk of cancer for anglers at the Portland Harbor Superfund Site due to direct contact with surface water or in-water sediment. However, anglers should consult the previous public health assessment regarding fish consumption to learn about potential risks from eating the fish caught from the harbor [1].

Exposure Scenario 3: Dockside Workers

EHAP assumed that dockside workers would contact beach sediment from industrial areas not accessible to the general public or recreational users of the Portland Harbor Superfund Site. It was also assumed that dockside workers would contact less surface water than recreational users, so total doses for dockside workers include only dermal (skin) and oral (swallowing) exposure to industrial beach sediment and do not include doses from exposure to surface water.

To calculate doses, EHAP used site-wide maximums of COPC concentrations for industrial beach sediment. This is the most protective of public health and is the most appropriate where composite samples represent an entire beach area. None of the six COPCs for industrial beach sediment had MRLs or RfDs for health risks other than cancer. Therefore, calculated doses could not be compared against MRLs to derive non-cancer HQs. However, the estimated non-cancer dose for benzo(a)pyrene (4.1E-06 mg/kg/day), which is the most toxic and abundant of the related PAHs measured in industrial beach sediment, was 410,000 times lower than any dose (10 mg/kg/day) that caused health effects in pregnant animals or their babies.

EHAP calculated lifetime cancer doses for the COPCs for industrial beach sediment, all PAHs, and multiplied them by their cancer slope factors to calculate cancer risks. Dockside workers may vary significantly in the frequency and extent to which they contact industrial beach sediment. Based on EPA interviews with current dockside workers, EHAP calculated two sets of doses and cancer risks based on “average” and “high-end” (Table 11) exposures to industrial beach sediment. Only the results for the “high-end” dockside workers are shown here (See Table 11). Note that dockside workers with “average” exposure to beach sediment would have lower doses than those calculated here for the “high-end” workers. Table 11, therefore, represents the “worst-case scenario” for dockside workers. Appendix C contains details about the different exposure assumptions used for “average” and “high-end” dockside workers.

Table 11. Cancer Risk for High-End Dockside Workers

Chemicals	Total Dose (mg/kg/day)	Cancer Slope Factor (1/mg/kg/day)	Cancer Risk	Contaminant of Concern (Y/N)
Benzo(a)anthracene	5.8E-06	0.73	4.2E-06	N
Benzo(a)pyrene	8.2E-06	7.3	6.0 E-05	N
Benzo(b)fluoranthene	6.2E-06	0.73	4.5E-06	N
Benzo(k)fluoranthene	4.8E-06	0.073	3.5E-07	N
Dibenzo(a,h)anthracene	1.9E-06	7.3	1.4E-05	N
Indeno(1,2,3-cd)pyrene	6.2E-06	0.73	4.5E-06	N
Total Cancer Risk	---	---	9.0E-05	N

Note: Numbers rounded to two significant digits
Mg/kg/day = Milligrams of chemical per kilogram of body weight per day

None of the COPCs for either average or high-end dockside workers contributed to a cancer risk greater than 1E-04. For high-end dockside workers, the overall cancer risk was close to the 1E-04 level (See Table 11). However, EHAP considers even a 1E-04 cancer risk to be a “low risk,” and does not expect that exposure to any chemicals from the Portland Harbor Superfund Site will harm the health of dockside workers.

Bacterial Considerations

Although this Public Health Assessment is focused on the public health implications of chemical exposures, there is some concern about bacterial contamination of the Portland Harbor Superfund Site. The City of Portland's Bureau of Environmental Services Combined Sewer Overflow (CSO) website states:

> "Portland's early sewers collected sewage from homes and businesses and stormwater runoff from streets in the same pipes. The mixture of sewage and stormwater in this combined sewer system drained directly to the Willamette River and the Columbia Slough without treatment.
>
> In the early 1950s, the city installed large pipes next to the river and slough to intercept sewage and carry it to Portland's first sewage treatment plant, the Columbia Boulevard Wastewater Treatment Plant. When it's not raining, all the sewage goes to the plant for treatment. But during wet weather, stormwater fills the combined sewer pipes to capacity and some sewage overflows." [15]

The Willamette Riverkeepers and ODEQ monitor the waters of Portland Harbor for *E. coli* [16]. The concentration of *E. coli* in water is reported as the "most probable number (MPN)" of *E. coli* per 100 milliliters (mL) of water (MPN/100 mL). The EPA standard for bacteria in recreational waters is 235 MPN/100 mL. At this concentration it is estimated that 8 out of 1000 people exposed in a recreational setting (i.e., swimming) would become ill. Across all seasons from 2002-2008, the Willamette Riverkeepers and ODEQ collected 100 samples from various locations within the Portland Harbor Superfund Site. Those 100 samples included a range from 0 to 1,986 MPN/100 mL. The median over the period was 21 MPN/100 mL and the average was 80 MPN/100 mL. Seven out of those 100 samples were higher than the EPA's 235 MPN/100 mL standard, and the maximum of 1,986 MPN/100 mL was collected at the north end of the Eastside Esplanade downstream from a CSO outfall on August 10, 2006. The other 6 samples in excess of the standard were in Swan Island Channel in December of 2002 and 2003 and at the SP&S Railroad Bridge in spring, winter, and fall seasons of 2002-2005. Swimming in or drinking water from locations near any CSO following rainfall when sewage is likely to spill over into the Willamette River could cause bacteria-related illness in people.

The city is in the process of completing Portland's Big Pipe project, which diverts all combined sewage flow to the sewage treatment plant in all but the most severe rainstorms. The west side Big Pipe project was completed in 2006. All the current CSOs are on the east side of the river, within the Portland City limits. Once the east side Big Pipe project is completed, then the combined sewage overflows will be rare events that occur only in the most severe rainstorms.

In most locations and for most of the year, bacterial hazards in the Harbor do not appear to be a significant threat to health. However, EHAP urges recreational users of the Portland Harbor Superfund Site, as well as other parts of the Lower Willamette River further upstream and downstream, to heed signs posted by the City of Portland discouraging swimming downstream from CSOs following rain storms when sewage overflows are most likely. EHAP also recommends that people who swim or recreate in the water from the Portland Harbor Superfund Site thoroughly wash all skin surfaces that were in contact with the water. Recreational users and anglers should especially wash hands before eating.

Physical hazards
Portland Harbor is an industrial harbor with traffic from ocean-going vessels and is bordered in many locations with busy streets and railroad lines. This industrial setting poses numerous physical safety hazards to recreational users including falling down steep embankments, becoming entangled in underwater debris while swimming, colliding with water craft while swimming or boating, or with road and train traffic while gaining access to the harbor. EHAP recommends that people recreating at the harbor exercise caution in choosing locations that avoid these physical hazards. EHAP also discourages recreational users from trespassing into industrial areas along the harbor where physical hazards are more likely to be present.

Uncertainties
There are many uncertainties involved in assessing the risks to public health from contaminants and other conditions in the environment. For example, it is impossible to know exactly how much water people accidentally swallow while swimming, so the assumptions used in this report’s dose calculations are based on a reasonable estimate that has been validated in studies done by the EPA. Likewise, the number of days per year that a recreational user might swim in the water at Portland Harbor will vary from one person to the next. In these types of cases, this report reflects assumptions that EHAP considers to be the “worst-case scenarios.” In the presence of uncertainty, using these types of worst-case assumptions is a way to ensure that the calculated doses and subsequent public health decisions and actions are protective of the most vulnerable populations.

Neither ATSDR nor EHAP typically assess bacteria-related risks at sites. However, bacterial contamination is known to be a significant current and historical problem in the Lower Willamette River, and EHAP felt that any Public Health Assessment omitting this important issue would be incomplete. While the assessment of bacteria-related health risks in this document is less quantitative than other sections presented, EHAP is confident that the analysis presented can be used to guide public health conclusions and recommendations that protect public health.

Evaluation of Health Outcome Data
The Superfund law requires that health outcome (i.e., mortality and morbidity) data (HOD) be considered in a public health assessment. This consideration is done using specific guidance in ATSDR’s *Public Health Assessment Guidance Manual*

[6]. The main requirements for evaluating HOD are presence of a completed human exposure pathway, great enough contaminant levels to result in measurable health effects, sufficient persons in the completed pathway for health effects to be measured, and a health outcome database in which disease rates for population of concern can be identified [6].

This site does not meet the requirements for including an evaluation of HOD in this public health assessment. Although completed human exposure pathways exist at this site, the exposed population is not sufficiently defined nor is a health outcome database established to permit meaningful measurements of possible site-related health effects as identified in existing HOD.

Children's Health

EHAP and ATSDR recognize that infants and children may be more vulnerable to exposures than adults in communities faced with contamination of their air, water, soil, or food. This vulnerability is a result of the following factors:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter, resulting in a greater likelihood to breathe dust, soil, and heavy vapors close to the ground.
- Children are smaller, resulting in higher doses of chemical exposure per body weight.
- The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

Because children depend on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at and around the Portland Harbor Superfund Site. It is important to note that the health-based screening values EHAP used for recreational beaches and surface water, where children are likely to have access to contaminants from the site, were derived from health guidelines that incorporate a high level of protectiveness for children and other sensitive individuals.

The likelihood of experiencing health effects from exposure to environmental contaminants depends on the amount of chemical a person is exposed to and the length of exposure time. Beaches identified as "Industrial Beaches" in this report, are inaccessible to children 1-6 years old because they are on private property with physical barriers and/or monitoring that would prevent non-employees or other unauthorized personnel from entering. Therefore, children's health was considered most extensively for "recreational beaches" and surface water. EHAP also assumed that children 1-6 years old would not be contacting in-water sediment from the bottom of the harbor as do avid anglers. If young children are contacting sediment in this way, they are not likely to spend as much time fishing as the avid anglers considered here, so the time they spend exposed to contaminants in this medium would be much less.

Community Concerns

In September 2007, EHAP attended the Superfund Field Day at Cathedral Park in

Portland, OR. EHAP set up a booth with an interactive display that was designed to engage people in talking about recreational behaviors in and around the Portland Harbor site and what their main concerns were. Participants were encouraged to place beads in jars characterizing their personal activities, or activities they have observed other community members or friends engaging in. The question posed was, "How do you (and others you know) use the river?" Seventy-eight booth participants "voted" by placing beads in whichever jar represented their categories of recreational use.

The 5 categories were:
1) Hiking/ Biking/ Picnicking (28)
2) Boating/ Sailing/ Canoeing (20)
3) Water Skiing/ Jet Boating/ Swimming (5)
4) Fishing/ Crayfish Hunting (7)
5) Other (see below) (18)

The "other" category included environmental clean-up activities, feeding ducks and birds, taking their dogs for a swim, catch & release fishing, and duck hunting.

EHAP collected a number of community concerns during the event related to recreational river use and chemical exposure. These concerns, and the actions that EHAP has taken to respond to them, are summarized below:

- People want information to understand current and future health effects from eating fish, and living and playing near the Superfund site.
    - The 2006 Public Health Assessment contains a comprehensive evaluation of the health effects of eating fish from Portland Harbor [1].
    - This report specifically addresses recreational activities such as wading, swimming, and playing on beaches along the Portland Harbor Superfund Site as well as the health effects of exposure to in-water (bottom) sediment incident to fishing the harbor.
- People want to know how much contact with the river is safe, and how much constitutes a health risk.
    - This report specifically addresses this concern.
- People have indicated a need for signs warning the community which areas and activities are unsafe.
    - The City of Portland is charged with maintaining signs at popular fishing locations explaining the fish advisories in place for Portland Harbor.
    - The City of Portland also maintains warning signs located at likely swimming access areas near CSOs.
    - Based on available data, EHAP has not identified any exposures to chemical contamination other than fish consumption to be a health concern.
- People want information on the pollutants in the river.
    - This report contains a comprehensive list of the contaminants measured in various media (beach sediment, in-water sediment, and surface water) and their concentrations.

- Community members are concerned about air quality (fumes/ air pollution) in and around the site, which are migrating into nearby neighborhoods.
    - This report did not address air quality concerns because air quality is a reflection of current operations and are regulated under permits by the Oregon Department of Environmental Quality. The Superfund process is focused on current and historical contamination to the water and sediments.
    - Information about air quality in the Portland neighborhoods surrounding the Portland Harbor Superfund Site can be found on the Oregon Department of Environmental Quality's website at: http://www.deq.state.or.us/aqi/aqiStationsPortland.aspx.
- People are bothered by industrial noise at all hours of the day and night.
    - EHAP acknowledges this concern and affirms that exposure to excess noise can harm people's health. However, EHAP is unable to address this concern specifically or quantitatively in this report.
- Some people want to know the effects of dredging the river and how it will disperse/displace contaminants into the river water and onto the beaches.
    - Site clean-up is outside EHAP's expertise. EHAP respectfully defers these concerns to the EPA, as they are coordinating the clean-up of the Portland Harbor Superfund Site.
- People want to understand how they can influence the clean-up process.
    - The EPA is coordinating the clean-up process, so any input/comments regarding clean-up should be directed to the EPA.
- Community members want to see the "polluter pays" concept enforced, and they want more companies to step forward to join the LWG.
    - EHAP acknowledges this concern and encourages community members to contact individual companies and the EPA, as the EPA is the regulatory/enforcement agency at the Portland Harbor Superfund Site. A list of potentially responsible parties can be found on the EPA website (see below).
- Community members want accessible, timely, and clear information about what's happening with the site.
    - EHAP strives to maintain transparency with the public and especially affected community members. Due to the complex nature of this site and the Public Health Assessment, this report took longer than anticipated to complete. EHAP apologizes for any inconvenience this delay has caused.
    - The EPA maintains a publicly accessible webpage on the Portland Harbor Superfund Site and the EPA's work there. This site can be found at: http://yosemite.epa.gov/R10/Cleanup.nsf/4ca19ed6a0fe79d588256ec90061cea7/75e7f27bd108f3eb88256f4a007ba018!OpenDocument.
- People want to know that field sampling and contaminant investigation work is of high quality, in order to support good clean-up decisions.
    - EHAP has confidence in EPA's data quality assurance process. EHAP also independently assesses whether data quality is adequate and

whether sufficient data have been collected to answer the health questions at hand. EHAP feels that the data from EPA's Round 2 Report were sufficient to support the analysis and conclusions presented here.

Conclusions

EHAP reached three important conclusions in this public health assessment.

EHAP concludes that swallowing and touching chemical contaminants in the water, beach sediment, and bottom sediment at the Portland Harbor Superfund Site is ***not*** *expected to harm people's health.* This is because the concentrations of chemicals measured in water, beach sediment, and bottom sediment are too low to harm the health of people who use the area for work, recreational, or fishing purposes. The concentrations of chemicals in water, beach sediment, and bottom sediment are also too low to harm the health of children who visit the site for recreational purposes.

Although not site-related, EHAP concludes that falling down steep embankments, potential collisions with large watercraft, entanglement or collision with underwater debris, and collisions with train and car traffic while recreating along the industrial and urban zones of the Portland Harbor Superfund Site area could physically injure people.

EHAP identified an additional hazard that is not specifically site-related. EHAP concludes that swallowing the water from combined sewer overflow (CSO) areas after a rain storm could cause bacteria-related illness. This is because the concentration of bacteria from sewage measured in the water in CSO areas following a rain storm could be high enough to cause bacteria-related illness in people who swallow small amounts of water while swimming or otherwise contacting water from the harbor (contact the City of Portland's Bureau of Environmental Services at 503-823-5328 for CSO locations). In dry weather and in areas upstream or further downstream from CSO areas, bacteria concentrations are too low to be a significant threat to people using the harbor recreationally or as anglers.

Recommendations

Based on EHAP's analysis of the available information about the Portland Harbor Superfund Site, EHAP has developed recommendations that, if followed, will protect the health of people who use the Portland Harbor Superfund Site.

EHAP recommends that the EPA and Responsible Parties continue efforts to clean-up sediments in the Portland Harbor Superfund Site that contribute to elevated chemical contaminant concentrations in fish.

Community members and their families can protect their health and the health of their children if they will follow the recommendations below:

- Do not trespass in industrial or other private properties within the Portland Harbor Superfund Site

- Minimize time spent in the portions of the site that are navigable and/or heavily used by watercraft
- Exercise caution when accessing the Willamette River in the Superfund area to avoid entanglement and collision with submerged debris and falling down steep embankments
- Not cross railroad tracks except at designated “railroad crossing” locations
- Continue to observe fish advisories for Portland Harbor posted by the Oregon Public Health Division’s Office of Environmental Public Health at http://www.oregon.gov/DHS/ph/envtox/fishconsumption.shtml#Portland.
- Avoid swimming in or contacting the water from CSO areas
- Thoroughly wash hands after contacting water from Portland Harbor before eating
- Thoroughly wash all body surfaces that come into contact with the water after swimming in or touching water from Portland Harbor
- Thoroughly wash any recreational equipment such as kayaks, oars, paddles, water skis, etc. after use at Portland Harbor

EHAP recommends that the City of Portland:

- Continue efforts to reduce the amount of sewage that spills into Portland Harbor from combined sewers
- Maintain signs marking CSO areas

Keep in mind that CSOs extend farther south than the actual Superfund Site study area. Other municipalities further down river may also have areas where sewage overflows into the Willamette River, which is not addressed in this PHA.

Public Health Action Plan

A Public Health Action Plan ensures that this Public Health Assessment identifies public health risks and provides a plan of action designed to reduce and prevent people’s exposure to hazardous substances in the environment. This plan includes a description of actions that will be taken by EHAP, in collaboration with other agencies, to implement the recommendations outlined in this document.

Public health actions that have been taken:

- Public release of a previous Public Health Assessment that addressed the public health risks of eating resident fish from the Portland Harbor Superfund Site [1]
- Implementation of fish advisories to protect the public from chemical contaminants in resident fish
- Public outreach, including securing mini-grants for non-profit organizations promoting healthy fish choices and healthy methods of fish preparation
- Public release of this Public Health Assessment
- Public release of summary fact sheet outlining the findings and recommendations from this report

Public health actions that will be taken by EHAP in the future:

- Within a year following the public comment period, EHAP will produce a final version of this Public Health Assessment incorporating public comments.
- In the next few months, conduct a community needs assessment to determine whether additional public health assessments focusing on transient users of the harbor or consumption of clams would be helpful or necessary.
- Present, discuss, and answer questions about the findings of this report in public meetings, public availability sessions, or other venues upon request within a month of public release.
- Within a few months, EHAP will conduct community outreach emphasizing the importance of caution regarding physical hazards along Portland Harbor.
- A few months following the community outreach regarding the physical hazards associated with accessing and using Portland Harbor, EHAP will monitor the frequency of accidental injuries occurring at Portland Harbor to assess the effectiveness of community outreach.
- Remain available to agency partners such as ODEQ and EPA as a consultative resource regarding human health impact and health education at the Portland Harbor Superfund Site.
- Remain available to community members to answer their questions and concerns about the public health impacts associated with use of the Portland Harbor Superfund Site.
- Remain available to the City of Portland Bureau of Environmental Services to consult regarding the design and placement of signs warning the public about swimming near CSOs.

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Certification

The Portland Harbor Public Health Assessment was prepared by the Oregon Department of Human Services under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It was completed in accordance with approved methodologies and a procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

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The Division of Health Assessment and Consultation (DHAC) ATSDR, has reviewed this health consultation and concurs with the findings.

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Appendix A. Comparison Values and Contaminant Screening

This appendix defines the various comparison values (CVs) that were used in this Public Health Assessment and describes the hierarchy by which they were chosen. This process is also explained in Chapter 7 of ATSDR's Public Health Assessment Guidance Manual [6]. Appendix B also explains the contaminant screening process.

CVs used in this document are listed below:

Environmental Media Evaluation Guides (EMEGs)
EMEGs are an estimate of contaminant concentrations low enough that ATSDR would not expect people to have a negative, non-cancerous health effect. EMEGs are based on ATSDR Minimal Risk Levels (MRLs, described below) and conservative assumptions about the public's contact with contaminated media, such as how much, how often, and for how long someone may be in contact with the contaminated media. MRLs also account for body weight. For residential beach sediment and surface water, EHAP used EMEGs for children. For in-water sediment and industrial beaches, EHAP used adult EMEGs because children are not likely to contact these media.

Cancer Risk Evaluation Guides (CREGs)
CREGs are an estimate of contaminant concentrations that are low enough that ATSDR would expect no more than one excess cancer case in a million (10^{-6}) persons exposed during their lifetime (70 years). ATSDR's CREGs are calculated from EPA's "cancer slope factors" (CSFs) used for oral exposures (swallowing a contaminant). For inhalation exposures (breathing in a contaminant), ATSDR uses EPA's "unit risk values". These values are based on EPA evaluations and assumptions about hypothetical cancer risks at low levels of exposure.

Reference Dose Media Evaluation Guides (RMEGs)
ATSDR derives RMEGs from EPA's oral reference doses, which are developed based on EPA evaluations. RMEGs represent chemical concentrations in water or soil at which daily human contact is not likely to cause negative, non-cancerous health effects. For residential beach sediment and surface water, EHAP used RMEGs for children. For in-water sediment and industrial beaches, EHAP used adult RMEGs because children are not likely to contact these media.

Minimal Risk Levels (MRLs)
An MRL is an estimate of daily human exposure – by a specified route and length of time -- to a dose of a chemical that is likely to be without a measurable risk of negative, noncancerous effects. MRLs are based on ATSDR evaluations. Acute MRLs are designed to evaluate exposures lasting 14 days or less. Intermediate MRLs are designed to evaluate exposures lasting from 15-364 days. Chronic MRLs are designed to evaluate exposures lasting for 1 year or longer. Oral exposures (swallowing the contaminant) are measured in milligrams per kilogram per day [mg/kg/day] and inhalation exposures (breathing the contaminant) are measured in parts per billion [ppb] or micrograms per cubic meter [$\mu g/m^3$].

Lifetime Health Advisory (LTHA)
A LTHA is derived by EPA, and is the concentration of a contaminant in water that a person could drink for their entire lifetime from childhood on without experiencing harmful health effects.

Maximum Contaminant Levels (MCL)
MCLs are derived by EPA as enforceable standards for municipal water systems. These standards assume that a person would use the water as a primary drinking water source for a lifetime without experiencing harmful health effects.

Soil Screening Levels (SSLs)
SSLs are soil contaminant concentrations derived by the EPA below which any negative health effects would be unlikely. SSLs are derived using EPA's reference doses (RfDs) as the basis and health-protective assumptions about exposure. EHAP used residential SSLs for recreational beach sediment and surface water screening, but because children are not likely to contact industrial beach sediment or in-water sediment, EHAP used industrial SSLs to screen those media.

Screening Levels (SL)
SLs are the same as SSL, but for contaminants concentrations in water instead of in soil.

Risk Based Concentrations (RBCs)
The Oregon Department of Environmental Quality (ODEQ) uses risk-based concentrations (RBCs) to screen environmental contaminants in soil, water, and air. RBCs are typically based on EPA toxicity factors for carcinogens and non-carcinogens.

ATSDR uses the hierarchy shown in Figure A1 (Adapted from Figure 7-2 in ATSDR's Public Health Assessment Guidance Manual [6]) to choose CVs for screening purposes.

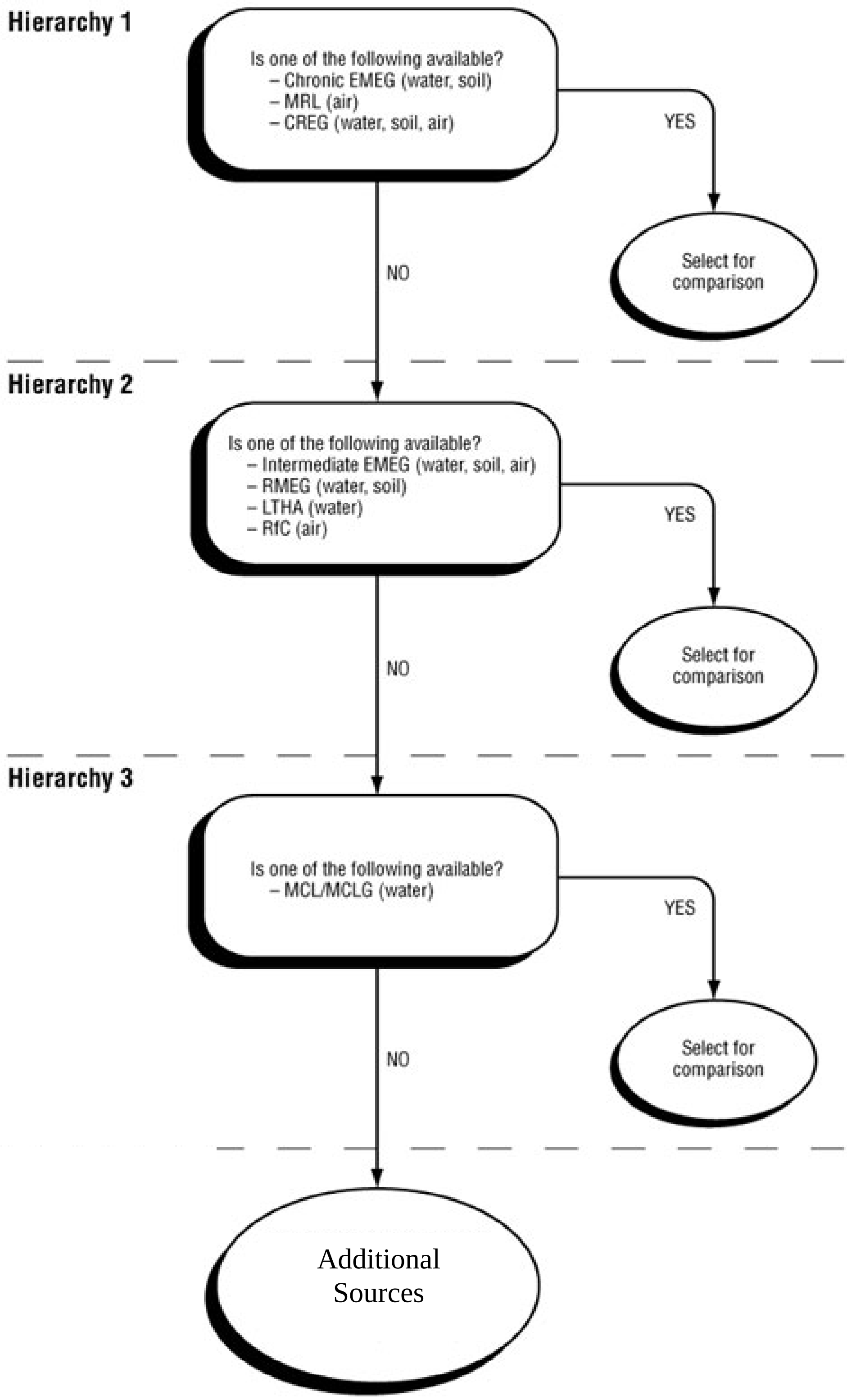

Figure A1. Environmental Guideline Hierarchy

In this Public Health Assessment, contaminants were screened by comparing the site-wide maximum contaminant concentration for each medium (beach sediment, in-water sediment, or surface water) against the best available CV according to the hierarchy described in Figure A1. Contaminant levels that were above their CV were labeled as contaminants of potential concern (COPC). A contaminant level above of its CV does not mean that harmful human health effects are expected, rather it is a tool used to identify and prioritize contaminants for the next phase of analysis.

Appendix B. Contaminant Screening

This appendix contains tables B1-B4 which show how contaminants measured in recreational beach sediment, industrial beach sediment, in-water sediment, and surface water at the Portland Harbor Superfund Site were screened against comparison values (CVs) for each contaminant in each medium. The CVs that EHAP used were provided by ATSDR and EPA according to the hierarchy shown in Figure A1 in Appendix A. This is according to the ATSDR Public Health Assessment Guidance Manual [6]. Appendix A describes ATSDR's CVs and their use.

Key for Table B1. Chr. = Chronic exposure is considered 1 year or longer.
Note: For recreational beach sediment screening, EHAP chose EMEGs and RMEGs for children and SSL for residential soil.

Table B1. Recreational Beach Sediment Contaminant Screening

Chemical name	Maximum Concentration (mg/kg)	Comparison Values (mg/kg)	Comparison Value Source	Contaminant of Potential Concern?
Metals				
Aluminum	2.2E+04	5.0E+04	chr. EMEG	N
Antimony	1.3E+01	2.0E+01	RMEG	N
Arsenic	9.9E+00	2.0E+01	chr. EMEG	N
Cadmium	2.3E-01	1.0E+01	chr. EMEG	N
Chromium	7.7E+01	2.0E+02	RMEG*	N
Copper	6.1E+02	5.0E+02	int. EMEG	Y
Lead	6.2E+01	4.0E+02	SSL	N
Mercury	1.8E-01	2.3E+01	SSL	N
Nickel	4.1E+01	1.0E+03	RMEG	N
Selenium	6.0E-02	3.0E+02	chr. EMEG	N
Silver	2.0E-01	3.0E+02	RMEG	N
Zinc	1.4E+02	2.0E+04	chr. EMEG	N
Polycyclic Aromatic Hydrocarbons				
2-Methylnaphthalene	8.3E-03	2.0E+03	chr. EMEG	N
Acenaphthene	3.2E-02	3.0E+03	RMEG	N

Chemical name	Maximum Concentration (mg/kg)	Comparison Values (mg/kg)	Comparison Value Source	Contaminant of Potential Concern?
Acenaphthylene	5.1E-02	3.0E+03	RMEG*	N
Anthracene	4.6E-02	2.0E+04	RMEG	N
Benzo(a)anthracene	2.1E-01	1.5E-01	SSL	Y
Benzo(a)pyrene	3.6E-01	1.0E-01	CREG	Y
Benzo(b)fluoranthene	3.1E-01	1.5E-01	SSL	Y
Benzo(g,h,i)perylene	3.1E-01	2.0E+03	RMEG*	N
Benzo(k)fluoranthene	2.7E-01	1.5E+00	SSL	N
Chrysene	3.1E-01	1.5E+01	SSL	N
Dibenzo(a,h)anthracene	3.3E-02	1.5E-02	SSL	Y
Fluoranthene	5.2E-01	2.0E+03	RMEG	N
Fluorene	6.5E-03	2.0E+03	RMEG	N
Indeno(1,2,3-cd)pyrene	2.8E-01	1.5E-01	SSL	Y
Naphthalene	4.1E-02	1.0E+03	RMEG	N
Phenanthrene	3.2E-01	2.0E+03	RMEG*	N
Pyrene	7.0E-01	2.0E+03	RMEG	N
Phthalates				
Bis(2-ethylhexyl) phthalate	2.3E-01	5.0E+01	CREG	N
Dibutyl phthalate	1.9E-01	5.0E+03	RMEG	N
Diethyl phthalate	4.8E-02	4.0E+04	RMEG	N
Semi-Volatile Organic Compounds (SVOCs)				
Carbazole	1.6E-02	2.4E+01	SSL 2004	N
Dibenzofuran	1.1E-02	1.5E+01	SSL 2004	N
Hexachlorobenzene	6.6E-04	4.0E-01	CREG	N
Phenols				
4-Methylphenol	9.5E-03	3.1E+02	SSL	N

Chemical name	Maximum Concentration (mg/kg)	Comparison Values (mg/kg)	Comparison Value Source	Contaminant of Potential Concern?
Pentachlorophenol	2.2E-02	6.0E+00	CREG	N
Polychlorinated Biphenyls				
Total PCB Aroclors	7.4E-02	4.0E-01	CREG	N
Dioxin/Furan				
Total Dioxin TEQ	8.1E-08	5.0E-05	chr. EMEG	N
Pesticides				
beta-Hexachlorocyclohexane	5.1E-03	4.0E-01	CREG	N
Endrin ketone	4.6E-04	2.0E+01	Chr. EMEG*	N
Total Chlordanes	5.9E-03	2.0E+00	CREG	N
Total DDD	1.3E-01	3.0E+00	CREG	N
Total DDE	1.0E-01	2.0E+00	CREG	N
Total DDT	1.4E-01	2.0E+00	CREG	N

*CV for surrogate compound

Key for Table B2. Chr. = Chronic exposure is considered 1 year or longer.
PRG = EPA's Primary Remediation Goal
Note: For industrial beach sediment screening, EHAP used adult EMEGs and RMEGs and SSL for industrial uses.

Table B2. Industrial Beach Sediment Contaminant Screening

Chemical	Maximum Detected (mg/kg)	Comparison Value (mg/kg)	Source of Comparison Value	Contaminant of Potential Concern?
Metals				
Aluminum	1.9E+04	7.0E+05	chr. EMEG	N
Antimony	3.3E-01	3.0E+02	RMEG	N
Arsenic	2.7E+00	2.0E+01	EMEG	N
Cadmium	7.3E-01	1.0E+02	chr. EMEG	N
Chromium	8.4E+01	1.4E+03	SSL	N
Copper	2.8E+01	7.0E+03	int. EMEG	N
Lead	5.0E+01	8.0E+02	SSL	N
Mercury	4.0E-02	2.8E+01	SSL	N
Nickel	6.9E+01	1.0E+04	RMEG	N
Silver	1.4E-01	4.0E+03	RMEG	N
Zinc	2.5E+02	2.0E+05	chr. EMEG	N
Polycyclic Aromatic Hydrocarbons				
2-Methylnaphthalene	2.2E+00	3.0E+04	chr. EMEG	N
Acenaphthene	3.6E+00	4.0E+04	RMEG	N
Acenaphthylene	5.0E+00	4.0E+04	RMEG*	N
Anthracene	8.0E+00	2.0E+05	RMEG	N
Benzo(a)anthracene	2.9E+01	2.1E+00	SSL	Y
Benzo(a)pyrene	4.1E+01	1.0E-01	CREG	Y
Benzo(b)fluoranthene	3.1E+01	2.1E+00	SSL	Y
Benzo(g,h,i)perylene	3.6E+01	2.0E+04	RMEG*	N
Benzo(k)fluoranthene	2.4E+01	2.1E+01	SSL	Y
Chrysene	3.8E+01	2.1E+02	SSL	N
Dibenzo(a,h)anthracene	9.5E+00	2.1E-01	SSL	Y
Fluoranthene	6.8E+01	3.0E+04	RMEG	N
Fluorene	3.6E+00	3.0E+04	RMEG	N
Indeno(1,2,3-cd)pyrene	3.1E+01	2.1E+00	SSL	Y
Naphthalene	7.0E+00	1.0E+04	RMEG	N

Chemical	Maximum Detected (mg/kg)	Comparison Value (mg/kg)	Source of Comparison Value	Contaminant of Potential Concern?
Phenanthrene	4.7E+01	2.0E+04	RMEG*	N
Pyrene	8.0E+01	2.0E+04	RMEG	N
Phthalates				
Bis(2-ethylhexyl) phthalate	5.0E-02	5.0E+01	CREG	N
Dibutyl phthalate	1.4E-02	7.0E+04	RMEG	N
SVOCs				
Carbazole	2.8E+00	8.6E+01	PRG 2004	N
Dibenzofuran	5.6E-01	1.6E+02	PRG 2005	N
Polychlorinated Biphenyls				
Total PCB Aroclors	1.6E+00	1.0E+01	chr. EMEG	N
Total PCB Congeners	1.1E-01	4.0E-01	CREG	N
Dioxin/Furan				
Total PCB TEQ	3.5E-05	7.0E-04	chr. EMEG	N
Total Dioxin TEQ	1.1E-06	7.0E-04	chr. EMEG	N
Pesticides				
alpha-Hexachlorocyclohexane	4.8E-04	1.0E-01	CREG	N
beta-Hexachlorocyclohexane	1.3E-03	4.0E-01	CREG	N
Total DDD	1.8E-03	7.2E+00	SSL	N
Total DDT	6.7E-03	4.0E+02	RMEG	N

*CV for surrogate compound

Key for CV sources in Table B3:
RBC = Risk-Based Concentration (Oregon DEQ)
Note: For in-water sediment screening, EHAP used adult EMEGs and RMEGs and SSL for industrial uses.

Table B3. In-Water Sediment Contaminant Screening

Chemical	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Contaminant of potential Concern
Metals				
Aluminum	4.6E+04	7.0E+05	chr. EMEG	N
Antimony	3.2E+01	3.0E+02	RMEG	N
Arsenic	7.6E+01	2.0E+01	chr. EMEG	Y
Barium	6.0E+03	1.0E+05	chr. EMEG	N
Beryllium	9.0E-01	1.0E+03	chr. EMEG	N
Cadmium	4.6E+01	1.0E+02	chr. EMEG	N
Chromium	7.7E+02	2.0E+03	RMEG*	N
Chromium hexavalent	2.1E+00	2.0E+03	RMEG	N
Cobalt	2.4E+01	7.0E+03	int. EMEG	N
Copper	1.1E+03	7.0E+03	int. EMEG	N
Iron	6.5E+04	7.2E+05	SSL	N
Lead	2.0E+03	8.0E+02	SSL	Y
Manganese	2.1E+03	4.0E+04	RMEG	N
Mercury	2.5E+00	2.8E+01	SSL	N
Nickel	5.9E+02	1.0E+04	RMEG	N
Selenium	2.0E+01	4.0E+03	chr. EMEG	N
Silver	1.5E+01	4.0E+03	RMEG	N
Thallium	2.7E+01	6.6E+01	SSL	N
Tin	5.4E+00	2.0E+05	int. EMEG	N
Titanium	3.5E+03	1.0E+05	SSL 2004	N

Chemical	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Contaminant of potential Concern
Vanadium	1.5E+02	2.0E+03	int. EMEG	N
Zinc	2.9E+03	2.0E+05	chr. EMEG	N
Butyltins				
Butyltin ion	7.4E-01	2.0E+02	chr. EMEG*	N
Dibutyltin dichloride	3.3E-02	4.0E+03	int. EMEG	N
Dibutyltin ion	2.7E+00	2.0E+02	chr. EMEG*	N
Monobutyltin trichloride	1.5E-02	2.0E+02	chr. EMEG*	N
Tetrabutyltin	1.0E+00	2.0E+02	chr. EMEG*	N
Tributyltin chloride	6.4E-02	2.0E+02	chr. EMEG*	N
Tributyltin ion	4.7E+01	2.0E+02	chr. EMEG*	N
Polycyclic Aromatic Hydrocarbons				
1,6,7-Trimethylnaphthalene	2.2E-01	1.0E+04	RMEG*	N
1-Methylnaphthalene	1.5E+00	1.0E+04	RMEG*	N
1-Methylphenanthrene	2.3E+00	2.0E+04	RMEG*	N
2,6-Dimethylnaphthalene	6.6E-01	1.0E+04	RMEG*	N
2-Methylnaphthalene	3.8E+01	1.0E+04	RMEG*	N
Acenaphthene	1.8E+02	4.0E+04	RMEG	N
Acenaphthylene	1.1E+01	4.0E+04	RMEG*	N
Anthracene	1.6E+02	2.0E+05	RMEG	N
Benzo(a)anthracene	1.2E+02	2.1E+01	SSL	Y
Benzo(a)pyrene	1.4E+02	1.0E-01	CREG	Y
Benzo(b)fluoranthene	1.3E+02	2.1E+01	SSL	Y
Benzo(e)pyrene	3.6E+01	2.0E+04	RMEG*	N
Benzo(g,h,i)perylene	1.0E+02	2.0E+04	RMEG*	N

Chemical	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Contaminant of potential Concern
Benzo(k)fluoranthene	6.8E+01	2.1E+01	SSL	Y
Chrysene	1.4E+02	2.1E+02	SSL	N
Dibenzo(a,h)anthracene	1.4E+01	2.1E-01	SSL	Y
Fluoranthene	3.4E+02	3.0E+04	RMEG	N
Fluorene	1.1E+02	3.0E+04	RMEG	N
Indeno(1,2,3-cd)pyrene	1.0E+02	2.1E+00	SSL	Y
Naphthalene	1.0E+02	1.0E+04	RMEG	N
Phenanthrene	4.0E+02	2.0E+04	RMEG*	N
Pyrene	4.2E+02	2.0E+04	RMEG	N
Phthalates				
Bis(2-ethylhexyl) phthalate	4.4E+02	5.0E+01	CREG	Y
Butylbenzyl phthalate	2.8E+00	1.0E+05	RMEG	N
Dibutyl phthalate	3.8E+00	7.0E+04	RMEG	N
Diethyl phthalate	3.7E-01	6.0E+05	RMEG	N
Dimethyl phthalate	1.7E-01	1.0E+05	SSL 2004	N
Di-n-octyl phthalate	1.5E+01	3.0E+05	int. EMEG	N
SVOCs				
1,2,4-Trichlorobenzene	3.1E-01	7.0E+03	RMEG	N
1,2-Dichlorobenzene	6.1E-01	2.0E+05	chr. EMEG	N
1,3-Dichlorobenzene	9.8E-02	1.0E+04	int. EMEG	N
1,4-Dichlorobenzene	7.3E-01	5.0E+04	chr. EMEG	N
3-Nitroaniline	4.8E-01	1.8E+02	SSL	N
4-Chloroaniline	1.0E-02	3.0E+03	RMEG	N
4-Nitroaniline	9.6E-02	1.8E+03	SSL	N

Chemical	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Contaminant of potential Concern
Aniline	6.7E-01	1.0E+02	CREG	N
Benzoic acid	4.1E+00	1.0E+06	RMEG	N
Benzyl alcohol	2.4E-01	3.1E+05	SSL	N
Bis(2-chloroethyl) ether	1.4E-02	6.0E-01	CREG	N
Carbazole	3.0E+01	8.6E+01	SSL 2004	N
Dibenzofuran	7.2E+00	1.6E+02	SSL 2004	N
Dibenzothiophene	7.5E+00	1.6E+02	SSL 2004*	N
Hexachlorobenzene	3.4E-01	4.0E-01	CREG	N
Hexachlorobutadiene	2.3E-01	9.0E+00	CREG	N
Hexachloroethane	1.5E+00	5.0E+01	CREG	N
N-Nitrosodiphenylamine	6.1E-02	1.0E+02	CREG	N
Perylene	1.4E+01	2.0E+04	RMEG*	N
Phenols				
2,3,4,5-Tetrachlorophenol	1.8E-01	2.0E+05	RMEG*	N
2,3,4,6;2,3,5,6-Tetrachlorophenol coelution	4.9E-02	2.0E+05	RMEG*	N
2,3,5,6-Tetrachlorophenol	2.8E-02	2.0E+05	RMEG*	N
2,4,5-Trichlorophenol	4.8E-02	7.0E+04	RMEG	N
2,4,6-Trichlorophenol	2.2E-01	6.0E+01	CREG	N
2,4-Dichlorophenol	1.2E-01	2.0E+03	RMEG	N
2,4-Dimethylphenol	3.0E-01	1.0E+04	RMEG	N
2-Chlorophenol	5.4E-02	4.0E+03	RMEG	N
2-Methylphenol	2.9E-01	4.0E+04	RMEG	N
4-Chloro-3-methylphenol	3.1E-01	2.0E+05	RMEG*	N
4-Methylphenol	1.4E+00	3.1E+03	SSL	N

Chemical	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Contaminant of potential Concern
Pentachlorophenol	8.4E+00	6.0E+00	CREG	Y
Phenol	6.8E-01	2.0E+05	RMEG	N
Polychlorinated Biphenyls				
Total PCB Aroclors	3.1E+01	1.0E+01	chr. EMEG	Y
Total PCB Congeners	3.5E+01	4.0E-01	CREG	Y
Total PCBs without dioxin-like congeners	3.5E+01	4.0E-01	CREG	Y
Dioxin/Furan				
Total Dioxin TEQ	1.7E-02	7.0E-04	chr. EMEG	Y
Total PCB TEQ	2.7E-04	7.0E-04	chr. EMEG	N
Pesticides				
Aldrin	6.9E-01	4.0E-02	CREG	Y
alpha-Hexachlorocyclohexane	1.0E-02	1.0E-01	CREG	N
beta-Hexachlorocyclohexane	2.0E-02	4.0E-01	CREG	N
delta-Hexachlorocyclohexane	5.3E-03	--		N
Dieldrin	3.6E-01	4.0E-02	CREG	Y
Diphenyl	6.7E-01	4.0E+04	RMEG	N
Endrin	3.0E-02	2.0E+02	chr. EMEG	N
Endrin aldehyde	6.6E-03	2.0E+02	chr. EMEG*	N
Endrin ketone	9.0E-02	2.0E+02	chr. EMEG*	N
gamma-Hexachlorocyclohexane	4.3E-01	7.0E+00	int. EMEG	N
Heptachlor	6.0E-03	2.0E-01	CREG	N
Heptachlor epoxide	1.7E-02	8.0E-02	CREG	N
Methoxychlor	3.4E-02	4.0E+03	RMEG	N
Mirex	5.0E-02	9.6E-02	SSL	N

Chemical	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Contaminant of potential Concern
Total Chlordanes	6.7E-01	2.0E+00	CREG	N
Total DDDs	3.0E+00	3.0E+00	CREG	Y
Total DDEs	2.5E+00	2.0E+00	CREG	Y
Total DDTs	1.3E+01	2.0E+00	CREG	Y
Total Endosulfans	2.7E-01	1.0E+03	chr. EMEG	N
Herbicides				
2,4,5-T	1.6E-02	7.0E+03	RMEG	N
2,4-D	3.3E+00	7.0E+03	RMEG	N
2,4-DB	3.4E-01	6.0E+03	RMEG	N
Dichloroprop	9.4E-03	7.0E+03	RMEG*	N
MCPA	3.6E-01	4.0E+02	RMEG	N
MCPP	4.2E+00	6.2E+02	SSL	N
Silvex	5.4E-03	6.0E+03	RMEG	N
VOCs				
1,1,1,2-Tetrachloroethane	2.9E-04	3.0E+01	CREG	N
1,1-Dichloroethane	3.1E-04	1.7E+01	SSL	N
1,2,3-Trichloropropane	8.6E-04	4.0E+03	RMEG	N
1,2-Dichlorobenzene	6.1E-01	2.0E+05	chr. EMEG	N
1,2-Dichloroethane	3.5E-04	8.0E+00	CREG	N
Acetone	1.6E-01	6.0E+05	RMEG	N
Benzene	8.9E-02	1.0E+01	CREG	N
Carbon disulfide	4.5E-03	7.0E+04	RMEG	N
Chlorobenzene	1.6E+01	1.0E+04	RMEG	N
Chloroethane	2.0E-02	6.2E+04	SSL	N

Chemical	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Contaminant of potential Concern
Chloroform	9.8E-02	7.0E+03	chr. EMEG	N
cis-1,2-Dichloroethene	2.7E-04	2.0E+05	int. EMEG	N
Dichlorodifluoromethane	2.9E-02	1.0E+05	RMEG	N
Ethylbenzene	4.7E-01	7.0E+04	RMEG	N
Isopropylbenzene	4.3E-01	7.0E+04	RMEG	N
Methyl isobutyl ketone	3.3E-04	5.2E+04	SSL	N
Methyl n-butyl ketone	1.8E-03	5.2E+04	SSL*	N
Methyl tert-butyl ether	8.4E-04	2.0E+05	int. EMEG	N
Methylene chloride	1.3E-03	9.0E+01	CREG	N
Methylethyl ketone	9.8E-03	4.0E+05	RMEG	N
Styrene	1.1E-03	1.0E+05	RMEG	N
Tetrachloroethene	9.1E-04	2.7E+00	SSL	N
Toluene	5.2E-02	1.0E+04	int. EMEG	N
trans-1,2-Dichloroethene	4.8E-04	1.0E+04	RMEG	N
Trichloroethene	9.1E-04	1.4E+01	SSL	N
Vinyl chloride	3.4E-04	5.0E-01	CREG	N
Total Xylenes	4.6E-01	1.0E+05	chr. EMEG	N
Petroleum				
Diesel Range Hydrocarbons	1.4E+04	7.0E+04	RBC	N
Gasoline Range Hydrocarbons	2.3E+02	1.3E+04	RBC	N
Lube Oil	9.4E+03	7.0E+04	RBC*	N
Motor oil	1.3E+02	7.0E+04	RBC*	N
Residual Range Hydrocarbons	1.8E+04	7.0E+04	RBC*	N

Chemical	Maximum Concentration (mg/kg)	Comparison Value (mg/kg)	Comparison Value Source	Contaminant of potential Concern
Conventionals				
Cyanide	5.4E+00	1.0E+04	RMEG	N
Perchlorate	2.7E+02	5.0E+02	chr. EMEG	N

*CV for surrogate compound

Note: For surface water screening, EHAP chose EMEGs and RMEGs for children and SL for residential drinking water.

Table B4. Surface Water Contaminant Screening

Chemical name	Maximum Concentration (µg/L)	Comparison Values (µg/L)	Comparison Value Source	Contaminant of Potential Concern?
Metals				
Aluminum	2.1E+02	1.0E+04	chr. EMEG	N
Antimony	6.0E-02	4.0E+00	RMEG	N
Arsenic	5.5E-01	2.0E-02	CREG	Y
Cadmium	3.0E-02	2.0E+00	chr. EMEG	N
Chromium	6.1E-01	1.0E+02	MCL	N
Copper	1.5E+00	1.0E+02	int. EMEG	N
Lead	2.8E-01	1.5E+01	MCL	N
Nickel	1.4E+00	2.0E+02	RMEG	N
Selenium	7.0E-01	5.0E+01	chr. EMEG	N
Silver	2.5E-02	5.0E+01	RMEG	N
Thallium	2.5E-02	5.0E-01	LTHA	N
Zinc	4.7E+00	3.0E+03	chr. EMEG	N
Butyltins				
Butyltin ion	2.0E-03	3.0E+00	chr. EMEG*	N
Dibutyltin ion	1.0E-03	3.0E+00	chr. EMEG*	N
Polycyclic Aromatic Hydrocarbons				
2-Methylnaphthalene	2.4E-02	4.0E+02	chr. EMEG	N
Acenaphthene	4.6E-03	6.0E+02	RMEG	N
Acenaphthylene	5.7E-03	6.0E+02	RMEG*	N
Anthracene	2.0E-03	3.0E+03	RMEG	N
Benzo(a)anthracene	5.1E-03	2.9E-02	SL	N

Chemical name	Maximum Concentration (µg/L)	Comparison Values (µg/L)	Comparison Value Source	Contaminant of Potential Concern?
Benzo(a)pyrene	1.2E-03	5.0E-03	CREG	N
Benzo(g,h,i)perylene	1.2E-03	3.0E+02	RMEG*	N
Benzo(k)fluoranthene	3.5E-03	2.9E-02	SL	N
Chrysene	4.2E-03	2.9E+00	SL	N
Dibenzo(a,h)anthracene	1.0E-04	2.9E-03	SL	N
Fluoranthene	2.0E-02	4.0E+02	RMEG	N
Fluorene	3.1E-03	4.0E+02	RMEG	N
Indeno(1,2,3-cd)pyrene	8.0E-04	2.9E-02	SL	N
Naphthalene	3.5E-02	2.0E+02	RMEG	N
Phenanthrene	7.3E-03	3.0E+02	RMEG*	N
Pyrene	8.3E-03	3.0E+02	RMEG	N
Phthalates				
Bis(2-ethylhexyl) phthalate	2.3E-02	3.0E+00	CREG	N
Butylbenzyl phthalate	2.0E-03	2.0E+03	RMEG	N
Dibutyl phthalate	2.0E-03	1.0E+03	RMEG	N
Diethyl phthalate	2.5E-03	8.0E+03	RMEG	N
SVOCs				
Hexachlorobenzene	7.3E-05	2.0E-02	CREG	N
Hexachlorobutadiene	3.5E-06	4.0E-01	CREG	N
Phenols				
4-Chloro-3-methylphenol	7.5E-02	5.0E+01	RMEG*	N
Phenol	6.7E-02	3.0E+03	RMEG	N
Polychlorinated Biphenyls				
Total PCB Congeners	6.1E-04	2.0E-02	CREG	N

Chemical name	Maximum Concentration (µg/L)	Comparison Values (µg/L)	Comparison Value Source	Contaminant of Potential Concern?
PCBs without dioxin-like congeners	5.9E-04	2.0E-02	CREG	N
Dioxin/Furan				
Dioxin TEQ	3.4E-07	1.0E-05	chr. EMEG	N
PCB TEQ	8.8E-09	1.0E-05	chr. EMEG	N
Pesticides				
Aldrin	2.7E-06	2.0E-03	CREG	N
alpha-Hexachlorocyclohexane	8.2E-05	6.0E-03	CREG	N
beta-Hexachlorocyclohexane	9.4E-06	2.0E-02	CREG	N
Dieldrin	4.3E-05	2.0E-03	CREG	N
Endrin	1.0E-06	3.0E+00	chr. EMEG	N
Endrin ketone	8.0E-07	3.0E+00	chr. EMEG*	N
gamma-Hexachlorocyclohexane	3.1E-05	6.1E-02	SL	N
Heptachlor	2.7E-07	8.0E-03	CREG	N
Heptachlor epoxide	5.2E-06	4.0E-03	CREG	N
Methoxychlor	3.4E-06	5.0E+01	RMEG	N
Total Chlordanes	1.3E-03	1.0E-01	CREG	N
Total DDDs	5.1E-04	1.0E-01	CREG	N
Total DDEs	5.1E-04	1.0E-01	CREG	N
Total DDTs	5.1E-04	1.0E-01	CREG	N
Total Endosulfans	7.7E-04	2.0E+01	chr. EMEG	N
Herbicides				
2,4-D	1.4E-01	1.0E+02	RMEG	N

*CV for surrogate compound

Appendix C. Exposure Assumptions and Dose Calculations

This appendix describes the formulas, methods, and assumptions used to calculate COPC doses for people in various exposure scenarios. The doses calculated here were used to calculate the risk for people exposed in these scenarios and to determine whether or not they might become ill because of contaminants at the Portland Harbor Superfund Site. For residential and industrial beach sediment and surface water, site-wide maximum concentrations of contaminants were used to calculate dose. This is very protective of human health, because people will likely be exposed to contaminants in various locations within the site boundaries, many of which have lower levels of contaminants than the maximum. For in-water sediment, an initial dose was calculated based on site-wide maximums, but then a more refined dose was calculated based on area-specific average concentrations for those COPCs that exceeded MRLs or cancer risk in excess of 1E-05 following the first round of calculation.

<u>Non-Cancer dose calculation</u>
Doses used for assessing risk of developing any illness other than cancer (non-cancer doses) were calculated as follows:

Total dose:

Total dose = $Dose_{sed} + Dose_{w}$

Where:
$Dose_{sed}$ = Total dose from exposure to sediment
$Dose_{w}$ = Total dose from exposure to surface water

And:
$Dose_{sed} = Dose_{os} + Dose_{ds}$

Where:
$Dose_{os}$ = Oral dose from sediment
$Dose_{ds}$ = Dermal dose from sediment

And:
$Dose_{w} = Dose_{ow} + Dose_{dw}$

Where:
$Dose_{ow}$ = Oral dose from surface water
$Dose_{dw}$ = Dermal dose from surface water

Terms in the next set of formulas are defined in Tables C1-C4.

$$Dose_{os} = \frac{C_{sed} \text{ x } IR_{sed} \text{ x } SF^{*} \text{ x } CF_{1} \text{ x } AF_{o} \text{ x } F \text{ x } ED}{AT_{nc} \text{ x } BW}$$

* Term used only in angler scenario for in-water sediment

$$Dose_{ds} = \frac{C_{sed} \text{ x } CF_1 \text{ x } SA \text{ x } SAF \text{ x } AF_{ds} \text{ x } SF^* \text{ x } F \text{ x } ED}{AT_{nc} \text{ x } BW}$$

* Term used only in angler scenario for in-water sediment

$$Dose_{ow} = \frac{C_w \text{ x } IR_w \text{ x } CF_2 \text{ x } CF_3 \text{ x } AF_o \text{ x } F \text{ x } ED}{AT_{nc} \text{ x } BW}$$

$$Dose_{dw} = \frac{C_w \text{ x } CF_3 \text{ x } CF_4 \text{ x } F \text{ x } ED \text{ x } t_{ev} \text{ x } SA \text{ x } K_p}{AT_{nc} \text{ x } BW}$$

<u>Cancer dose calculation</u>

Formulas for calculating cancer doses are identical to those above except that that the averaging time (AT_{nc}) is replaced by the averaging time for cancer (AT_c) which is 25,550 days (365 days/year over a 70 year lifetime). This is common practice in cancer dose calculation because cancer results from the cumulative effect of multiple factors over an entire lifetime. Therefore, this calculation method incorporates the carcinogen dose from a particular source (the Portland Harbor Superfund Site in this case) over an entire lifetime.

<u>Exposure assumptions</u>

Tables C1-C5 describe in detail the assumptions and terms that were used in calculating contaminant doses for various exposure scenarios. Tables C1 and C2 define exposure assumptions for recreational users, while Tables C3 and C4 lay out the same information for the angler scenario. Table C5 describes the exposure assumptions used in calculating doses for dockside workers via industrial beach sediment.

Table C1. Sediment exposure factors for recreational users

Exposure Factor	Description	Value		Units	Rationale
		Adult	Child		
C_{sed}	Concentration of contaminant in sediment	---	---	mg/kg	Chemical specific; Beach sediment for Adults and Children, In-water sediment for workers
IR_{sed}	Oral intake rate for sediment	100	200	mg/day	ATSDR default values
CF_1	Conversion factor 1	0.000001	0.000001	kg/mg	Converts mg to kg
AF_o	Oral bioavailability factor	1	1	---	Assumes 100% absorption to be protective of health
F	Frequency	94	94	days/year	Professional judgment. For recreational users: 5 days/week during summer (13 weeks), 1 day/week during spring/fall (26 weeks), 1 day/month during winter (3 months)
ED	Exposure duration	30	6	years	ATSDR default values
AT_c	Averaging time, cancer	25550	25550	days	ATSDR default value, based on 70 year lifetime
AT_{nc}	Averaging time, non-cancer	10950	2190	days	ATSDR default values, based on 30, and 6 exposure durations
BW	Body weight	70	16	kg	ATSDR default values
SA	Exposed skin surface area	4656	2094	cm^2	ATSDR default values (24% of adult male total surface area and 30% of total child [1-6 years old] total surface area)
SAF	Sediment Adherence Factor	0.328	3.327	mg/day-cm^2	EPA guidance (Risk Assessment Guidance for Superfund [RAGS] Section E Appendix C) [17]

Exposure Factor	Description	Value		Units	Rationale
		Adult	Child		
AF_{ds}	Dermal absorption factor for sediment	---	---	---	Chemical specific; See Table C6 for list of COPCs and their AF_{ds}

Table C2. Surface water exposure factors for recreational users

Exposure Factor	Description	Value		Units	Rationale
		Adult	Child		
C_w	Concentration of contaminant in surface water	---	---	µg/L	Chemical specific
IR_w	Oral intake rate for surface water	50	50	mL/event	ATSDR Guidance
CF_2	Conversion factor 2	0.001	0.001	L/mL	Converts mL to L
CF_3	Conversion factor 3	0.001	0.001	mg/µg	Converts µg to mg
CF_4	Conversion factor 4	0.001	0.001	L/cm^3	Converts cm^3 to L (For dermal dose equation this conversion factor is used instead of CF_1)
AF_o	Oral bioavailability factor	1	1	---	Assumes 100% absorption to be protective of health
F	Frequency	26	65	events/year	Professional judgment. For recreational users: 2 days/week swimming during summer (13 weeks) for adults and 5 days/week swimming during summer (13 weeks) for children
ED	Exposure duration	30	6	years	ATSDR default values
AT_c	Averaging time, cancer	25550	25550	days	ATSDR default value, based on 70 year lifetime
AT_{nc}	Averaging time, non-cancer	10950	2190	days	ATSDR default values, based on 30, and 6 year exposure durations
BW	Body weight	70	16	kg	ATSDR default values

Exposure Factor	Description	Value		Units	Rationale
		Adult	Child		
SA	Exposed skin surface area	19400	6978	cm^2	ATSDR default values for total body surface area
K_p	Dermal permeability coefficient chemicals in water	---	---	cm/hour	Chemical specific; K_p values for each chemical shown in Table C7.
t_{ev}	Duration of swimming event	1	1	hour/event	Professional judgment

Table C3. In-water sediment exposure factors for anglers

Exposure Factor	Description	Value	Units	Rationale
C_{sed}	Concentration of contaminant in medium	---	mg/kg	Chemical specific
IR_{sed}	Oral intake rate for sediment	50	mg/day	Recommended by EPA Region 10
CF_1	Conversion factor 1	1E-06	kg/mg	Converts mg to kg
AF_o	Oral bioavailability factor	1	---	Assumes 100% absorption to be protective of health
F	Frequency	156	days/year	Professional judgment. 3 days/week for entire year
ED	Exposure duration	30	years	Recommended value for residential occupancy (EPA)
AT_c	Averaging time, cancer	25550	days	ATSDR default value, based on 70 year lifetime
AT_{nc}	Averaging time, non-cancer	10950	days	Based on 30 year exposure duration
BW	Body weight	70	kg	ATSDR default values
SF	Sediment Contact Frequency	0.25	---	Recommended by EPA Region 10

Exposure Factor	Description	Value	Units	Rationale
SA	Exposed skin surface area	1980	cm^2	ATSDR default for hands and forearms
SAF	Sediment Adherence Factor	0.328	mg/day-cm^2	EPA guidance (RAGS Section E Appendix C) [17]
AF_{ds}	Dermal absorption factor for sediment		---	Chemical specific (shown in Table C6)

Table C4. Surface water exposure factors for anglers

Exposure Factor	Description	Value	Units	Rationale
C_w	Concentration of contaminant in medium	---	µg/L	Chemical specific
IR_w	Oral intake rate for surface water	25	mL/day	Professional judgment. Assumes accidental ingestion of water that gets on hands while fishing
CF_2	Conversion factor 2	0.001	L/mL	Converts mL to L
CF_3	Conversion factor 3	0.001	mg/µg	Converts µg/mg
CF_4	Conversion factor 4	0.001	L/cm^3	Converts cm^3 to L (For dermal dose equation this conversion factor is used instead of CF_1)
AF_o	Oral bioavailability factor	1	---	Assumes 100% absorption to be protective of health
F	Frequency	156	days/year	Professional judgment. 3 days/week for entire year
ED	Exposure duration	30	years	Recommended value for residential occupancy (EPA)
AT_c	Averaging time, cancer	25550	days	ATSDR default value, based on 70 year lifetime
AT_{nc}	Averaging time, non-cancer	10950	days	Based on 30 year exposure duration
BW	Body weight	70	kg	ATSDR default values
SA	Exposed skin surface area	1980	cm^2	ATSDR default for hands and forearms
K_p	Dermal permeability coefficient for chemicals in water	---	cm/hour	Chemical specific (Shown in Table C7)
t_{ev}	Duration of skin exposure to surface water during day of fishing	1	hour/day	Professional judgment

Table C5. Industrial beach sediment exposure factors for dockside workers

Exposure Factor	Description	Value		Units	Rationale
		Average	High-End		
C_{sed}	Concentration of contaminant in sediment	---	---	mg/kg	Chemical specific
IR_{sed}	Oral intake rate for sediment	50	200	mg/day	Recommended by EPA Region 10
CF_1	Conversion factor 1	0.000001	0.000001	kg/mg	Converts mg to kg
AF_o	Oral bioavailability factor	1	1	---	Assumes 100% absorption to be protective of health
F	Frequency	44	50	days/year	Professional judgment. 1 Day per week with direct sediment contact for 219 or 250 work weeks/year. EPA recommendation for occupational exposure.
ED	Exposure duration	9	25	years	Recommended value for occupational exposures (EPA)
AT_c	Averaging time, cancer	25550	25550	days	ATSDR default value, based on 70 year lifetime
AT_{nc}	Averaging time, non-cancer	3285	9125	days	Based on 25 year exposure duration respectively
BW	Body weight	70	70	kg	ATSDR default values
SA	Exposed skin surface area	3300	3300	cm^2	EPA recommended for adult industrial scenario
SAF	Sediment Adherence Factor	0.02	0.2	mg/day-cm^2	EPA guidance (RAGS Section E Appendix C) [17]
AF_{ds}	Dermal absorption factor for sediment	---		---	Chemical specific (Shown in Table C6)

Table C6. AF_{ds} values for COPCs in beach and in-water sediment

COPC	AF_{ds}
Antimony	---
Arsenic	0.03
Cadmium	0.001
Chromium	---
Copper	---
Iron	---
Lead	---
Thallium	---
Tributyltin ion	---
Benzo(a)anthracene	0.13
Benzo(a)pyrene	0.13
Benzo(b)fluoranthene	0.13
Benzo(k)fluoranthene	0.13
Chrysene	0.13
Dibenzo(a,h)anthracene	0.13
Indeno(1,2,3-cd)pyrene	0.13
Bis(2-ethylhexyl) phthalate	---
Pentachlorophenol	0.25
Total PCB Aroclors	0.14
Total PCB Congeners	0.14
Total PCBs without dioxin-like congeners	0.14
Total Dioxin TEQ	0.03
Total PCB TEQ	0.03
Aldrin	---
Dieldrin	---
Mirex	---
Total DDDs	0.03
Total DDEs	0.03
Total DDTs	0.03
Perchlorate	---

"---" = No AF_{ds} for this chemical exists. For these chemicals, no dermal dose from sediment was calculated.

Table C7. K_p values for COPCs

COPC	K_p
Antimony	0.001
Arsenic	0.001
Cadmium	0.001
Chromium	0.002
Copper	0.001
Lead	0.0001
Thallium	0.001
Benzo(a)anthracene	0.47
Benzo(a)pyrene	0.7
Benzo(k)fluoranthene	---
Chrysene	0.47
Dibenzo(a,h)anthracene	1.5
Indeno(1,2,3-cd)pyrene	1
Bis(2-ethylhexyl) phthalate	0.025
Total PCB Aroclors	0.75
Total PCB Congeners	0.75
Total PCBs without dioxin-like congeners	0.75
Total Dioxin TEQ	0.81
Total PCB TEQ	0.75
Aldrin	0.0014
Dieldrin	0.012
Total DDDs	0.18
Total DDEs	0.16
Total DDTs	0.27

"---" = No K_p exists for this chemical. For these chemicals, no dermal dose from water was calculated.

Tables C8-C10 show how total doses were obtained by combining doses from sediment and surface water for the recreational user and angler scenarios. Because total doses for dockside workers were calculated only from industrial beach sediment exposure, the total dose was equal to the dose from sediment, so a table was not necessary. Only doses for non-cancer effects are shown here. Doses for cancer effects were calculated the same way, but the sediment and water components of the doses were calculated using the cancer averaging time (25,550 days) instead of the non-cancer averaging time (ED x 365 days). This means that doses for estimating cancer risk are averaged over a lifetime of exposure, so the values are always lower than the doses for estimating non-cancer risks. Risk evaluation is described in the Public Health Implications subsection of the discussion in the main body of this report.

Table C8. Total dose to adult recreational users for COPCs identified

Chemical	Dose from Sediment (mg/kg/day)	+	Dose from Surface Water (mg/kg/day)	=	Total Dose (mg/kg/day)
Arsenic	5.31098E-06	+	3.88423E-08	=	5.34982E-06
Copper	0.000222951	+	1.02402E-07	=	0.000223053
Benzo(a)anthracene	2.30647E-07	+	4.71745E-08	=	2.77821E-07
Benzo(a)pyrene	3.95394E-07	+	1.62973E-08	=	4.11691E-07
Benzo(b)fluoranthene	3.40478E-07	+	---	=	3.40478E-07
Dibenzo(a,h)anthracene	3.62445E-08	+	3.05533E-09	=	3.92998E-08
Indeno(1,2,3-cd)pyrene	3.07529E-07	+	1.58143E-08	=	3.23343E-07

"---" = Contaminant not measured in surface water

Table C9. Total dose to children (1-6 years old) recreational users for COPCs

Chemical	Dose from Sediment (mg/kg/day)	+	Dose from Surface Water (mg/kg/day)	=	Total Dose (mg/kg/day)
Arsenic	6.51742E-05	+	3.48795E-07	=	6.5523E-05
Copper	0.001950822	+	9.19551E-07	=	0.001951741
Benzo(a)anthracene	3.73734E-06	+	1.87392E-07	=	3.92473E-06
Benzo(a)pyrene	6.40686E-06	+	6.45343E-08	=	6.4714E-06
Benzo(b)fluoranthene	5.51702E-06	+	---	=	5.51702E-06
Dibenzo(a,h)anthracene	5.87296E-07	+	1.20567E-08	=	5.99352E-07
Indeno(1,2,3-cd)pyrene	4.98311E-06	+	6.24999E-08	=	5.04561E-06

"---" = Contaminant not measured in surface water

Table C10. Total dose to anglers for COPCs (based on site-wide maximum concentration for in-water sediment)

Chemical	Dose from Sediment (mg/kg/day)	+	Dose from Surface Water (mg/kg/day)	=	Total Dose (mg/kg/day)
Arsenic	8.01817E-06		9.06021E-08		8.11E-06
Lead	0.000148826		4.26167E-08		0.000149
Benzo(a)anthracene	2.46231E-05		2.95026E-08		2.47E-05
Benzo(a)pyrene	2.87269E-05		1.01228E-08		2.87E-05
Benzo(b)fluoranthene	2.6675E-05		---		2.67E-05
Benzo(k)fluoranthene	1.38505E-05		5.30003E-10		1.39E-05
Dibenzo(a,h)anthracene	2.87269E-06		1.88351E-09		2.87E-06
Indeno(1,2,3-cd)pyrene	2.05192E-05		9.78126E-09		2.05E-05
Bis(2-ethylhexyl) phthalate	3.35812E-05		1.04575E-08		3.36E-05
Pentachlorophenol	2.7261E-06		---		2.73E-06
Total PCB Aroclors	6.62998E-06		---		6.63E-06
Total PCB Congeners	7.62353E-06		5.61609E-09		7.63E-06
Total PCBs without dioxin-like congeners	7.53107E-06		5.47346E-09		7.54E-06
Total Dioxin TEQ	1.75739E-09		3.34736E-12		1.76E-09
Aldrin	5.27378E-08		4.65291E-13		5.27E-08
Dieldrin	2.71703E-08		1.29088E-11		2.72E-08
Total DDDs	3.22848E-07		1.18764E-09		3.24E-07
Total DDEs	2.68121E-07		1.06433E-09		2.69E-07
Total DDTs	1.32957E-06		1.74254E-09		1.33E-06

"---" = Contaminant not measured in surface water

Appendix D. Dose and Health Risk Calculation for the Heavy Metal, Lead

The heavy metal, lead (Pb), was one of the COPCs identified for anglers exposed to in-water sediment while fishing. Because scientists, including toxicologists, chemists, and medical doctors, have been studying Pb for so long, there is sufficient information to calculate actual blood Pb concentrations (PbB) in micrograms per deciliter (µg/dL) based on concentrations in various media. The process described here estimates the total PbB from all sources in the environment and not only from the Portland Harbor Superfund Site. EHAP used site-specific information about exposure and Pb concentrations where known. For non-site-specific exposure scenarios, defaults established by EPA and approved by ATSDR were used. EHAP used 5 µg/dL PbB as the threshold for adverse health effects in adults (EHAP assumed that only adults would come into contact with in-water sediment from Portland Harbor).

The basic formula used to calculate PbB at the Portland Harbor Superfund Site is:

$$PbB = \delta_S TPb_{sed} + \delta_S TPb_S + \delta_D TPb_D + \delta_W TPb_W + \delta_{AO} TPb_{AO} + \delta_{AI} TPb_{AI} + \delta_F TPb_F$$

Where:

δ = Media specific slope factor. This term is used to estimate how Pb concentration in each media translates into PbB in µg/dL.

T = Relative time spent in contact with each media. Table D1 shows the assumptions used for this term for each medium.

Pb = Concentration of Pb in each medium.

Table D1 shows the meanings of terms in the above formula, the range of estimated PbB from each media, and overall PbB for anglers using the Portland Harbor Superfund Site. References indicated in the footnotes can be found in the References section of this document.

Table D1. Blood Lead Levels for anglers at the Portland Harbor Superfund Site

$PbB=\delta_S TPb_{sed} + \delta_S TPb_s + \delta_D TPb_D + \delta_W TPb_W + \delta_{AO} TPb_{AO} + \delta_{AI} TPb_{AI} + \delta_F TPb_F$					Slope Factor (δ)[b]		Blood Lead (µg/dL)	
Media	Term in Formula	Concentration (Pb)	Units	Relative Time Spent (T)	Low	High	Low[c]	High[d]
Outdoor Air	AO	0.00712[e]	µg/m^3	0.14[f]	1.75	2.7	0.0017444	0.00269136
Indoor air	AI	0.002136[g]	µg/m^3	0.86[h]	1.75	2.7	0.00321468	0.004959792
Food	F	5[i]	µg/day	1	0.014	0.034	0.07	0.17
Water	W	4[i]	µg/L	1[j]	0.03	0.06	0.12	0.24
In-water sediment (site-wide maximum)	sed	2000[k]	mg/kg	0.035[l]	0.001	0.003	0.07	0.21
Soil from off-site	S	70[i]	mg/kg	0.965[m]	0.001	0.003	0.06755	0.20265
Dust	D	70[i]	mg/kg	1	0.0021	0.0096	0.147	0.672
Total	---	---	---	---	---	---	**0.47950908**	**1.502301152**

The total estimated PbB (1.5 µg/dL) is 16.7 times lower than the 25 µg/dL action level for adults established by the Centers for Disease Control and Prevention (CDC). Some studies have shown that Pb can harm health in adults and children at levels much lower than the CDC's 25 µg/dL action level [18]. Fortunately, even using worst-case exposure assumptions, the estimated PbB is not significantly different than the national average PbB for adults in the United States (1.56 µg/dL) [19]. EHAP did not consider Pb in in-

[b] Slope Factors for adults (because only adults contact in-water sediment) from 18. ATSDR, *Toxicological Profile for Lead*, D.o.H.a.H. Services, Editor. 2007: Atlanta, GA.
[c] Calculated using low slope factor
[d] Calculated using high slope factor
[e] Six year average ambient air Pb concentration measured at National Ambient Air Quality stations within 2 miles of the site (See Table D2)
[f] 8 hours a day for 156 days a year spent fishing at the Portland Harbor Superfund Site divided by 24 hours a day for 365 days in a year (1248 hrs/8760 hrs = 0.14)
[g] EPA recommends using 30 percent of outdoor air concentration for indoor air
[h] Any time not spent out on the Portland Harbor Superfund Site fishing (1-0.14 = 0.86)
[i] 18. ATSDR, *Toxicological Profile for Lead*, D.o.H.a.H. Services, Editor. 2007: Atlanta, GA.
[j] Assumes tap water, not site-specific surface water. EHAP chose this value because the default Pb concentration in tap water was higher than the average concentration of lead in surface water at the site. Using the default tap water value is more protective of health.
[k] Site-wide maximum in-water sediment concentration measured in Round 2 Data Report for the Portland Harbor Superfund Site
[l] Twenty-five percent of the relative time spent fishing (0.25 x 0.14 = 0.035). This assumes, based on interviews with anglers, that anglers only contact in-water sediment about a quarter of the time they spend fishing.
[m] Contact with soil from anywhere other than in-water sediment from the Portland Harbor Superfund Site (1-0.035 = 0.965)

water sediment to be a significant health hazard to anglers or anyone else using the Portland Harbor Superfund Site.

Table D2. Air Concentrations from National Ambient Air Quality Monitoring Stations near the Portland Harbor Superfund Site for Lead (PM_{10})

Location	Distance from site (miles)	Annual Mean Concentration (µg/m^3)	Year
N Roselawn Ave.	1.5	0.00577	2003
N Roselawn Ave.	1.5	0.0082	2004
N Roselawn Ave.	1.5	0.01113	2005
N Roselawn Ave.	1.5	0.00663	2006
N Roselawn Ave.	1.5	0.00787	2007
N Roselawn Ave.	1.5	0.00517	2008
1706 NW 24th Ave.	1	0.00512	2006
Overall Mean		0.007127[n]	

[n] Used in Table D1 for outdoor air concentration of Pb

Appendix E. Detailed Health Information for Arsenic, Benzo(a)pyrene, and Total Dioxin TEQ

Arsenic

Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds [12].

At high levels, inorganic arsenic can cause death. Exposure to lower levels for a long time can cause a discoloration of the skin and the appearance of small corns or warts. Several studies have shown that ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhaling inorganic arsenic can increase a person's risk for lung cancer [12].

The concentrations of arsenic in sediments and surface water at the Portland Harbor Superfund Site are too low to harm people's health or to cause any of the health problems mentioned above. See the Public Health Implications section of the Discussion in this document for more details about arsenic at the Portland Harbor Superfund Site specifically.

Benzo(a)pyrene

Polycyclic aromatic hydrocarbons (PAHs), including benzo(a)pyrene, are a class of chemicals that occur naturally in coal, crude oil, and gasoline. PAHs also are created from the incomplete burning of coal, oil and gas, garbage, or tobacco. Many products contain PAHs including creosote wood preservatives, roofing tar, certain medicines, dyes, and pesticides [7].

PAHs enter the atmosphere from vehicle exhaust, emissions from residential and industrial furnaces, tobacco smoke, volcanoes, and forest fires. PAHs may attach to particles produced during emission and in the air. PAHs may contaminate surface water and groundwater [7].

According to the International Agency for Research on Cancer, the National Toxicology Program, and EPA, certain PAHs have been classified as definite, probable, or possible carcinogens (cancer-causing agents). Some people who have breathed or touched mixtures of PAHs for long periods have developed cancer. In laboratory animals, some PAHs have caused lung, stomach, or skin cancer [7].

The concentrations of PAHs, including benzo(a)pyrene, in sediments and surface water at the Portland Harbor Superfund Site are too low to harm people's health or to cause any of the health problems mentioned above. See the Public Health Implications section of the Discussion in this document for more details about benzo(a)pyrene at the Portland Harbor Superfund Site specifically.

Total Dioxin TEQ

Total dioxin TEQ (Toxic Equivalency Quotient) is a sum of the concentrations of several chemicals of similar structure adjusted for their relative toxicity to the most potent chemical in the class, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Dioxins, furans, and dioxin-like polychlorinated biphenyls (PCBs) are the abbreviated names for a family of chemicals that share a similar chemical structure and are included in the total dioxin TEQ. Most of these chemicals are not manufactured or produced intentionally but are created when other chemicals or products are made. These chemicals may be created during burning of forests or household trash; chlorine bleaching of pulp and paper; or manufacturing or processing of certain types of chemicals, such as pesticides. Most soil and water samples contain trace amounts of dioxins and furans [14].

The most well-known and well-studied chemical in the dioxin, furan, and dioxin-like PCBs family is 2,3,7,8-TCDD. The EPA and the International Agency for Research on Cancer have classified 2,3,7,8-TCDD as likely to cause cancer in people. People exposed to high levels of dioxin have developed a skin condition called chloracne. Liver injury also may occur after heavy prolonged exposures. More research is needed to determine the health effects on people of all chemicals in the dioxin, furan, and dioxin-like PCBs family, but some studies suggest effects on hormonal balance and immune responses [14].

The concentrations of chemicals that make up total dioxin TEQ in sediments and surface water at the Portland Harbor Superfund Site are too low to harm people's health or to cause any of the health problems mentioned above. See the Public Health Implications section of the Discussion in this document for more details about the total dioxin TEQ at the Portland Harbor Superfund Site specifically.

Appendix F. Glossary of Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR serves the public by using the best science available to take responsive public health actions and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the EPA, which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption:	How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.
Acute Exposure:	Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.
Additive Effect:	A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.
ATSDR:	The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.
Background Level:	An average or expected amount of a chemical in a specific environment or amounts of chemicals that occur naturally in a specific environment.
Bioavailability:	See **Relative Bioavailability**.
Cancer:	A group of diseases which occur when cells in the body become abnormal and grow, or multiply out of control.
Carcinogen:	Any substance shown to cause tumors or cancer in experimental studies.
CERCLA:	See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure:	A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.
Completed Exposure Pathway:	See **Exposure Pathway**.
Comparison Value: **(CVs)**	Concentrations of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):	**CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.
Concern:	A belief or worry that chemicals in the environment might cause harm to people.
Concentration:	How much or the amount of a substance present in a certain amount of soil, water, air, or food.
Contaminant:	See **Environmental Contaminant**.
Delayed Health Effect:	A disease or injury that happens as a result of exposures that may have occurred far in the past.
Dermal Contact:	A chemical getting onto your skin. (See **Route of Exposure**).
Dose:	The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".
Dose / Response:	The relationship between the amount of exposure (dose) and the change in body function or health that result.
Duration:	The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant:	A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.
Environmental Media:	Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.
U.S. Environmental Protection Agency (EPA):	The federal agency that develops and enforces environmental laws to protect the environment and the public's health.
Epidemiology:	The study of the different factors that determine how often, in how many people, and in which people disease will occur.
Exposure:	Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)
Exposure Assessment:	The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.
Exposure Pathway:	A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having 5 parts: 1. Source of Contamination, 2. Environmental Media and Transport Mechanism, 3. Point of Exposure, 4. Route of Exposure, and 5. Receptor Population. When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.
Frequency:	How often a person is exposed to a chemical over time; for example, every day, once a week, or twice a month.
Hazardous Waste:	Substances that have been released or thrown away into the environment and under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Indeterminate Public Health Hazard: This category of hazard is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

kg Kilogram or 1000 grams. Usually used here as part of the dose unit mg/kg/day meaning mg (contaminant)/kg (body weight)/day.

LOAEL: **L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.

µg Microgram or 1 millionth of 1 gram. Usually used here as part of the concentration of contaminants in water (µg/Liter).

mg Milligram or 1 thousandth of 1 gram. Usually used here as in a concentration of contaminant in soil mg contaminant/kg soil or as in the dose unit mg/kg/day meaning mg (contaminant)/kg (body weight)/day.

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used to predict adverse health effects.

NPL: The **N**ational **P**riorities **L**ist (which is part of **Superfund**.). A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL: **N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard: This hazard category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: This hazard category is used in ATSDR's Public Health Assessment documents for sites where there is evidence there are no exposures to site-related chemicals.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Some examples include: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, or the backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area or the number of people in a certain area.

PRP: **P**otentially **R**esponsible **P**arty. A company, government, or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of a site.

Public Health Assessment(s): See **PHA**.

Public Health Hazard: This hazard category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each is defined in the Glossary. The categories are:
– Urgent Public Health Hazard
– Public Health Hazard
– Indeterminate Public Health Hazard
– No Apparent Public Health Hazard
– No Public Health Hazard

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.

Relative Bioavailability: The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.

Route of Exposure:	The way a chemical can get into a person's body. There are three exposure routes: – breathing (also called inhalation), – eating or drinking (also called ingestion), and – getting something on the skin (also called dermal contact).
Safety Factor:	Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is <u>not</u> likely to cause harm to people.
SARA:	The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting from chemical exposures at hazardous waste sites.
Sample Size:	The number of people that are needed for a health study.
Sample:	A small number of people chosen from a larger population (See **Population**).
Source (of Contamination):	The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.
Special Populations:	People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.
Statistics:	A branch of the math process of collecting, looking at, and summarizing data or information.
Superfund Site:	See **NPL**.
Survey:	A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.
Toxic:	Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor**.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.